S. A. E. JOURNAL

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W. G. WALL, *President* COKER F. CLARKSON, *Secretary* C. B. WHITTELSEY, *Treasurer*

Vol. XXII June, 1928 No. 6

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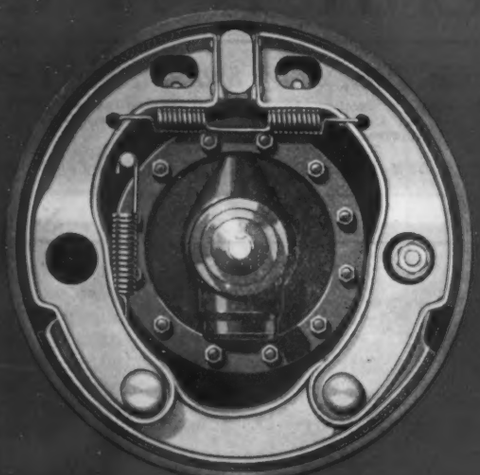
The purpose of meetings of the Society is largely to provide a forum for the presentation of straightforward and frank discussion. Discussion of this kind is encouraged. However, owing to the nature of the Society as an organization, it cannot be responsible for statements or opinions advanced in papers or in discussions at its meetings. The Constitution of the Society has long contained a provision to this effect.



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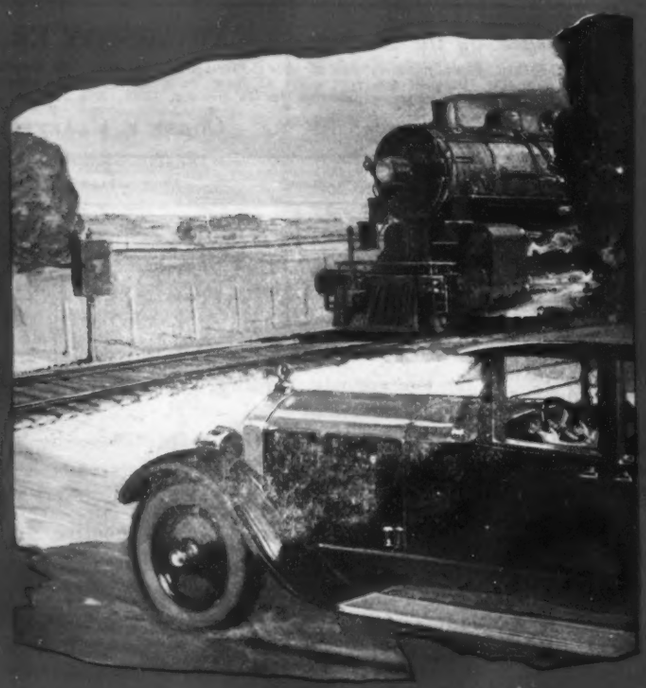

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S. A. E. JOURNAL

Vol. XXII June, 1928 No. 6

Nine Technical Sessions Announced

Twenty-One Papers and Addresses Scheduled for Summer Meeting—More Than 900 Reservations Filed

With more than 900 reservations received for the Summer Meeting at Quebec, June 26 to 29, the biggest Summer Meeting ever held by the Society is definitely assured. It is expected that all of the 1100 rooms and baths available at the Chateau Frontenac will be engaged before the opening session on Tuesday evening.

Although a larger number of the members than ever before will drive to the Summer Meeting, more special cars and trains will be assigned to the Sections than heretofore because of the larger registration. The New York Special leaves Grand Central Terminal on Monday, June 25, at 3:07 p.m., and the Detroit Special leaves the Michigan Central Station at 1:45 p.m. the same day. Regular trains connecting with the New York Special leave the City of Washington at 9 a.m., and West Philadelphia at 11:57 a.m. The special cars to be attached to the Detroit Special depart on Sunday, June 24, as follows: Chicago, 11:45 p.m.; Indianapolis, 10:30 p.m.; Monday, June 25, Dayton, 12:48 a.m.; Cleveland, 8:20 a.m.; and Buffalo, 2:00 p.m. The Cleveland and Buffalo cars connect with the Detroit Special at Toronto.

Railroad Certificates

Railroad certificates entitling members and their families to the 1½-fare rate for the round trip were mailed to the members about May 10. Tickets may not be purchased before June 22 or after June 28. Pullman reservations should, however, be made as early as possible so that sufficient special equipment can be made available on the S.A.E. Specials.

In addition to the fare and one-half privilege, the railroads have also granted the 1 3/5-fare privilege, for which a 30-day limit for the return transportation is permitted instead of the 5-day limit for the 1½-fare certificates.

The final time-limit for leaving Quebec allowed by the 1½-fare certificates is July 5. Validation of railroad tickets at Quebec will not be necessary. In buying tickets, members should specify the Canadian Pacific route.

Special arrangements have been made by the Chateau for the customs inspection. All hand-baggage will be inspected en route and special customs officials will be at the Chateau to inspect the trunks shipped direct. On returning, trucks may be passed by the customs officials at the Chateau and shipped direct to their destination.

...ce of hypnotism was complet...
Whereas patients often unconsciously resist anesthetics, even though completely under their influence.

Quebec Only New World City on 'Beautiful' List

Sir Michael Sadler, Oxford Master, Names 20 Towns as Most Attractive

OXFORD, England, Nov. 2 (AP).—City beautiful experts in the United States and South America will not agree with Sir Michael Sadler, who has made up a list of twenty of the world's most beautiful cities. Only Quebec is mentioned in North or South America.

Sir Michael, who is the master of University College, Oxford, makes the following selections without assigning any order: Rome, Florence, Venice, Vienna, Athens, Constantinople, Paris, Stockholm, The Hague, Budapest, Nurnberg, Rotenburg, Dijon, Angouleme, Quebec, Angra, Benares, Edinburgh, Bath and Oxford.

Lone Physician Battles Epidemic to Save 150

The Canadian customs regulations permit each person leaving Canada to carry $100 worth of goods duty free. However, the American officials are supposed to limit the importation of certain goods.

The Chateau Frontenac

The Chateau Frontenac is so different from the usual hotel that it deserves special mention in any advance story of the Summer Meeting. From the river, looking up at the towering structure above the retaining wall supporting Dufferin Terrace, it is difficult to conceive of the Chateau as a twentieth-century building. The hotel is completely fireproof, the old part destroyed by fire in 1925 having been entirely rebuilt. All of the public rooms, with the exception of the main lobby, overlook Dufferin Terrace and the St. Lawrence River. The total cost of the Chateau has been estimated at more than $10,000,000. As in all Canadian hostelries, light wines may be obtained with meals.

The Technical Program

The final technical program is given on the following page. Abstracts of the papers are also printed herewith to give members an opportunity to decide which papers they desire to study in advance of the meeting. A form for requesting preprints is on p. 11 of the advertising section. Members desiring to take part in the discussions should obtain the preprints of papers in which they are interested. Although no definite date can be set on which preprints will be available, they will be mailed to those who request them as soon as they are received from the printer.

Preprints of papers to be presented at the Research Session probably will not be available.

As members have made hotel reservations for 14 children, the suggestion has been made that a special session

For complete advance information on the Summer Meeting, see the March issue of The Journal, p. 293; the April issue, p. 403; the May issue, p. 503; the special S.A.E. Time-Table, mailed April 4, and the Meetings Bulletin, mailed May 10.

1928 Summer Meeting Technical Program

June 26-29

Quebec

Tuesday, June 26

2:00 P. M.—STANDARDS SESSION

H. M. Crane, *Chairman*

See p. 697 for Division Reports

8:00 P. M.—GENERAL SESSION

President W. G. Wall, *Presiding*

Address—President W. G. Wall

Address—Major E. G. E. Beaumont, President of the Institution of Automobile Engineers

The Engineer as a Business Man—Norman Shidle, Chilton Class Journal Co.

Baron Shiba's High-Speed Motion Pictures

Wednesday, June 27

10:00 A. M.—CHASSIS SESSION

B. B. Bachman, *Chairman*

Synchronism of Front Wheels—D. Sensaud de Lavaud

Discussion of M. de Lavaud's Annual Meeting paper on Independently Sprung Front Wheels as Remedy for Shimmy—Improvement of Suspension and Steering. (Printed on p. 623)

Legislation on Automobile Brakes—E. H. Lockwood and H. W. Best, Sheffield Scientific School

European Roads and American Cars—Tore Franzen, Detroit Steel Products Co.

2:00 P. M.—TRANSMISSION-PRODUCTION SESSION

D. D. Ormsby, *Chairman*

Ground Gears and Transmission Design—H. L. F. Orcutt, The Gear Grinding Co., Ltd.

Prepared Discussion by P. L. Tenney of the Muncie Products Division of the General Motors Corporation

Simultaneous Inspection and Correction of Gears in Production—Charles H. Logue and R. B. Fehr, Copland Gear Lapping Syndicate

7:30 P. M.—BUSINESS SESSION

President W. G. Wall, *Presiding*

Reports of Committees

8:00 P. M.—FOREIGN SESSION

W. J. Davidson, *Chairman*

The Airplane in Canadian Exploration—A. M. Narraway, Assistant Director and Chief Aerial Surveys Engineer, Topographical Survey of Canada

Trend in European Passenger-Car Design—Maurice Platt, *The Motor*, (London)

Thursday, June 28

10:00 A. M.—ENGINE SESSION

W. R. Strickland, *Chairman*

A New Electrical Engine Indicator—Dr. E. J. Martin and D. F. Caris, General Motors Corporation Research Laboratories

Poppet-Valve Spring Design—Alfred Moorhouse and W. R. Griswold, Packard Motor Car Co.

Methods of Obtaining Greater Power from Engines than Formerly—T. J. Litle, Jr., Marmon Motor Car Co.

Crankshaft Distortion Research—C. A. Norman, The Ohio State University. (To be read by title only.)

10:00 A. M.—TRANSPORTATION SESSION

F. K. Glynn, *Chairman*

Cooperation in Transport—Major E. G. E. Beaumont, Anglo-American Oil Co.

Motorcoach Operation—James L. Smith, Gray Coach Lines

Motorcoach, Motor Truck and Railway—R. A. C. Henry, Director of the Bureau of Economics, Canadian National Railways

2:00 P. M.—TRANSMISSION SESSION

W. T. Fishleigh, *Chairman*

The Sensaud de Lavaud Automatic Transmission—D. Sensaud de Lavaud

Front Wheel Drives—Are They Coming or Going?—Herbert Chase, Erickson Co.

8:00 P. M.—BODY-DESIGN SESSION

H. Ledyard Towle, *Chairman*

The Basic Appeal of the Motor Car to Women with Relation to Body Lines and Interior Trimming—Paul Thomas, Style Expert and Sales Promotion Manager, Cheney Brothers Co.

Friday, June 29

10:00 A. M.—RESEARCH SESSION

H. L. Horning, *Chairman*

The Influence of Fuel Characteristics on Acceleration—Donald B. Brooks, Bureau of Standards

Dew-Point and Vapor-Pressure Measurements of Gasoline—O. C. Bridgeman, Bureau of Standards

TO OBTAIN PREPRINTS OF PAPERS, CHECK AND MAIL LIST ON P. 11 OF ADVERTISING SECTION

be scheduled for kiddy-car design and operation.

Committee Meetings

In addition to the meeting of the Council, meetings of almost all the Administrative Committees of the Society will be held during the Summer Meeting. Members of these Committees will be notified on arrival at Quebec of the time and place for each meeting.

Sightseeing Schedule

Five organized sightseeing trips have been scheduled for the meeting as follows:

Tuesday, 2 p. m.—Trip in caleches around the Plains of Abraham and through old Quebec.

Wednesday, 10 a. m.—Trip to Montmorency Falls and Kent House.

Wednesday, 3 p. m.—Visit to Spencerwood.

Thursday, 2 p. m.—Trip to Ste. Anne de Beaupré.

Saturday, 7 a. m.—Saguenay post-convention cruise.

More than 50 members have made reservations for the post-convention cruise down the St. Lawrence River to Cape Eternity and Tadousac, and up the Saguenay River to Chicoutimi.

Members may also wish to make a special trip to Murray Bay, where the golf course is reported to be on the top of a mountain.

Every member should attend the Summer Meeting at Quebec in order to hear and take part in the discussion of the important papers that will be presented. It is a duty you owe your company and yourself. More engineers and executives are attending this year than ever before. — W. G. WALL, *President*.

The Country Fair

Members who have sent in their reservations for the Summer Meeting have received the announcement prepared by the Country Fair Committee. This event will be held on the first evening of the meeting. Committees appointed by the various Sections have arranged for special Section stunts for this affair.

Delco-Remy To Publish the *Daily SAE*

No Summer Meeting would be complete without its *Daily SAE* devoted to the sense and nonsense of the meeting. The Meetings Committee is pleased that the Delco-Remy Corp. will again undertake the *Daily SAE*. It is understood that this year it will come out in slightly different dress and with a distinct change in character from those of former years. The fact that adequate printing facilities are conveniently located in Quebec will make the midnight Paul Revere rides of previous years unnecessary.

Abstracts of Technical Papers

GENERAL SESSION

The Engineer As a Business Man

NORMAN G. SHIDLE

Premising that the fundamentals which govern business progress for people in general are applicable to engineers, the author discusses some of the factors that are influential in determining success or failure.

The engineer is cautioned against considering as something apart from his job the difficulties he encounters in dealing with the individuals in his own department and in his contacts with those in other departments. It is pointed out that if persons and circumstances cramp his style for any extended period the fault probably is not with the other persons, the other departments, or the management, but with the engineer himself, because the perfecting of conditions under which he can fulfill his greatest mission is essentially a part of his own job.

Included in the paper are such topics as the engineer as a salesman within his own organization, that is, a salesman of his ideas to his associates and to the management; the relative inarticulateness of engineers and the extent to which it hampers the progress of individual engineers; the relation between engineering and the sales department; and the inferiority complex as an obstacle to success.

Emphasis is placed on the idea that, in the future, engineering thinking must be business thinking. The engineer must think as a business man who sees his engineering program as an integral part of that business which provides not only his living but his opportunity for service, and who realizes the necessity for trying to understand management problems as well as strictly engineering problems.

CHASSIS SESSION

Automobile Brake Legislation

E. H. LOCKWOOD AND H. W. BEST

This paper discusses safety of brake equipment as a joint problem for the manufacturer, the motor-vehicle administrator and the car user. It is pointed out that four-wheel brakes, which had become standard equipment for new automobiles by the end of 1927, introduced the safety element of the ability to make an emergency stop in about one-half the former distance and at the same time lessened the tendency of the car to skid. Other safety elements that should be contained in the brake mechanism are mentioned also.

Present brake laws, enacted during the period of two-wheel brakes, prescribe that all automobiles shall be equipped with two sets of brakes having separate means of application. The laws have been complied with by the ordinary two-wheel brakes, but have been technically violated by many of the four-wheel brake mechanisms, in which the two sets of brakes are not separately applied. The violation has occurred in this Country and in Europe, the violators being some of the best-known makes of automobile. This situation has been met by the motor-vehicle departments in a broad-minded way by registering the cars in question provisionally, pending final decision of the technical violation.

The Eastern Conference of Motor Vehicle Administrators recently approved a proposed new brake-law which will be reported to the member States and Canadian Provinces for legal enactment.

The proposed law is quoted by the authors, with approval of its provisions as well adapted to present motor-vehicles. Exception is taken to one clause, which apparently requires that the two sets of brakes shall be separately applied and thus may cause nearly the same embarrassment as present laws. It is argued that,

in four-wheel-brake mechanisms, separate operation of the service and parking brakes adds to the complication of the mechanism without adding essentially to its safety. The importance is urged of cooperation between automobile manufacturers and the State motor-vehicle departments in solving problems relating to the safer operation and control of motor-vehicles on the public highways.

European Roads and American Cars

TORE FRANZEN

This paper covers the findings resulting from a first-hand study of European motor-car suspension problems, with particular reference to such complaints as "weak springs" and "striking through" as they relate to American cars. Some suggestions and proposed solutions of a general nature are indicated.

TRANSMISSION-PRODUCTION SESSION

Ground-Gears and Transmission Design

H. F. L. ORCUTT

Ground teeth for transmission gears are advocated because they can be made to the same degree of accuracy as the other fine working-parts of a motor-car.

The designing engineer is held responsible by the production department for conditions unfavorable to the adoption of gear grinding. Mr. Orcutt believes that cluster gears should be avoided because it is impossible to finish them accurately.

Designs are recommended that will provide ample center distance to avoid pinions with a small number of teeth. The unmodified involute is recommended as the most satisfactory form of tooth.

Fundamental principles of rigid shafts and correct bearing-arrangements are laid down, and the degree of accuracy is specified for the fitting parts. Transmission-case design still needs development and study to avoid resonance.

Spigot bearings receive special consideration. Two designs of transmissions are submitted, in one of which the spigot bearing is eliminated. Simplification is sought by reducing the number of gear sizes used. Four-speed transmissions require gears with only four different numbers of teeth.

Simultaneous Inspection and Correction of Gears in Production

CHARLES H. LOGUE AND R. B. FEHR

The gear-correcting process described is a means whereby spur and helical gears are corrected to give such a high degree of uniformity in spacing and profile that the gears become interchangeable. Most important, they acquire a "crown face" which enables them to run with an unusual degree of quietness under practical conditions. This is essentially an inspection-correction process, as it automatically finds and at the same time eliminates errors.

The important element of the process is the lap, which is of chilled cast-iron, gray cast-iron, or type metal, and is made by casting in a sand mold around a steel chill which is cut to approximate the gear to be corrected, but has a face-width several times that of the gear. When completed the lap looks like a wide-faced internal gear.

The gear-correcting machine is of relatively simple construction and performs three main functions: (*a*) It provides reciprocating motion for the gear, (*b*) it causes mutual pressure between the faces of the gear teeth and the lap, and (*c*) it advances the gear one tooth with respect to the lap at the completion of every cycle, thereby assuring uniformity of spacing and contour.

Unlike the many instruments and methods that have been devised for merely detecting the errors in gears, the Copland inspector-corrector not only inspects the gears but corrects them after all other operations, including heat-treating, have been performed. It will do this work, according to the authors, without adding to the total cost of the gears, for the feeds of the gear-cutting machines can be increased considerably, thus compensating for the time required by the gear-correcting operation. The resultant gears will be interchangeable, thus eliminating almost all matching-up and rejections in the final tests.

FOREIGN SESSION

The Airplane in Canadian Exploration

A. M. NARRAWAY

The remarkable advance in the science of aviation throughout the world during the last five years has opened up new areas in development for many countries. This is true particularly for Canada, where previously considerably more than 80 per cent of the country was unmapped because of its inaccessibility, and the tremendous natural resources lying undeveloped were only slightly known. Aerial surveys are now bringing these resources to light. They are enabling expert examiners, for the first time in history, readily to search them out, and they allow investigations of detail to be combined with permanent records revealing a birds-eye view of the whole of an area.

Canada has been using the airplane as a workhorse rather than a racehorse. This new arm of the Service has been developed so successfully in Canada that it has succeeded in almost completely revolutionizing natural-resources investigations as well as mapping. During the last five years more than 200,000 sq. miles of hitherto inaccessible forest and mineral areas have been successfully and accurately mapped by methods originated and developed in the Dominion. This has enabled the introduction of and given an impetus to the production of the national topographic map of Canada by a uniform and coordinated system of mapping throughout the whole country.

In addition to and apart from this mapping work, many specific applications relating to geological, water power, forestry, and other investigations have been made possible. One of the most notable has been the classifying by type of more than 50,000 sq. miles of forested lands in the interests of development and protection.

There is no doubt that aerial surveys are moving ahead the development of the natural resources of the country by at least a generation. A very real need exists for a really practical airplane having ample endurance to take advantage of all the clear photographic weather and having good visibility factors to enable good navigation to be done.

Current Automobile Practice in Europe

MAURICE PLATT

The paper is divided into four sections, the first of which classifies popular chassis types and gives their outstanding features of design, dimensional details, performance figures and other statistics. In the second section the principal trends in chassis design are described, such as the increased use of six-cylinder engines, servo braking, and one-shot chassis-lubrication systems. The trends in these and in matters of detail design for the last five years are shown by graphs.

Developments in body work and equipment are described in the third section, which deals with rigid and flexible fabric-covered bodies, fashions in style and appearance, sunshine salons, permanently fitted luggage-containers, dip-twist head-lamps and so on.

The fourth section consists of a brief survey of chassis changes which are on the tapis and undergoing experiment, such as free-wheel transmissions, independent wheel-springing, supercharging, oil radiators, and front-wheel drive.

ENGINE SESSION

A New Type of Electrical Engine-Indicator

E. J. MARTIN AND D. F. CARIS

The qualifications of a satisfactory engine indicator are listed, emphasis being placed upon fundamental qualifications rather than on those which might lead to ease of operation only. Indicators heretofore developed are classified and the more successful ones in each class are described and discussed briefly to lead the reader to an appreciation of indicator problems and the ingenuity used in attempts to solve them.

The operation of the new electrical indicator then described and illustrated depends upon the variation of resistance in two carbon piles which form two branches of a Wheatstone bridge. The pressure element is a thin steel disc mounted flush with the inner wall of the combustion chamber. The disc is connected by means of an invar rod to a cantilever spring, the movement of which causes a variation of the resistance of the carbon piles. The spring is so designed that maximum pressures produce displacements of less than 0.0005 in. With such an arrangement, practically all of the elastic restoring forces are in the spring; the diaphragm being used merely as a seal, the elastic constants of which may be neglected.

Diagrams are recorded by means of either an ordinary oscillograph or a cathode-ray oscillograph, the latter being portable and easily operated. A number of diagrams taken with the new indicator illustrate its performance under various conditions. Diagrams taken under conditions of violent detonation are smooth in outline, and the work done with the new indicator up to the present indicates that, if a "detonation wave" exists, it is of such a nature that it has not been recorded by any indicator yet developed.

The new indicator units used up to the present have natural frequencies above 3000 cycles per sec., a feature which enables the faithful recording of phenomena having frequencies as high as 800 cycles per sec. Other units are being constructed which will be capable of recording accurately frequencies of several thousand cycles per second. With the new units and the cathode-ray oscillograph it is expected to investigate still further the nature of detonation.

Work is now being done toward the development of an indicator unit that will combine the functions of an indicator and a

(*Continued on page* 689)

Chronicle and Comment

ON behalf of the officers of the Society, I wish to congratulate the retiring Section officers for their splendid work. It is hoped that they will feel compensated for their efforts by the realization that their activities have been of inestimable value not only to the members of their own Sections but, through the medium of the S.A.E. JOURNAL and otherwise, to the entire Society.

I wish to take this opportunity to assure the incoming Section officers of our heartiest support as they assume their new duties. I consider the Sections the backbone of the Society, and I feel confident that the officers chosen to conduct the affairs of the various Sections during the coming year will distinguish themselves by their able leadership.—W. G. WALL, President.

Nine Hundred Reservations for Quebec!

THE question with regard to the Summer Meeting at Quebec is becoming not so much one of whether you are going to Quebec as whether you will be able to secure the reservation you want. Nine hundred reservations were received as a result of the first *Meetings Bulletin*, and it is expected that the Chateau Frontenac will be booked to capacity before the special trains leave for Quebec. No reservations will be made for members in any other hotels, as suitable accommodations cannot be obtained.

The Meetings Committee is to be congratulated on the excellent technical program that has been arranged and for the other events that will make the 1928 Summer Meeting memorable. Detailed information regarding the meeting is given in the leading articles in this and the May issues of THE JOURNAL.

Detroit Section Takes the Lead

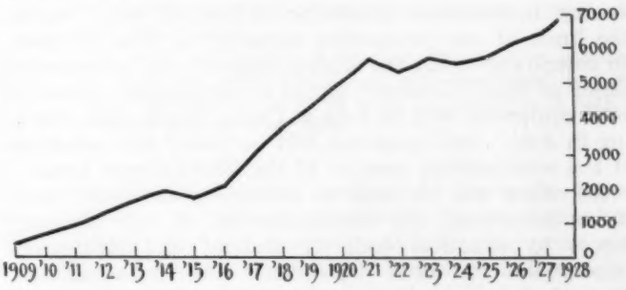
ON April 25 the Detroit Section passed the Metropolitan Section, the standing of the two Sections on June 1 being 931 members in the Detroit Section and 897 in the Metropolitan Section. The Metropolitan Section had been leading since October, 1927, but with the increased Section activities in Detroit it was inevitable for the Section there to win, the potential Society membership in Detroit being much greater than that in New York City. There is good reason to expect that the Detroit Section membership will reach 1500 within the next 2 or 3 years.

The main reason for the success of the Detroit Section, which during the last year has had an aggregate attendance of close to 6000 at its meetings, and an average attendance of about 475, was admirably stated by B. J. Lemon, upon his accepting the chairmanship of the Detroit Section for next year, at the May 7 meeting. He said in part:

> The factor that I believe has been most responsible for the success of the Detroit Section is the leadership of Walt Fishleigh. His was the real leadership—not a dictatorship; a leadership which spelled enthusiasm for the cause; a leadership which meant attention to minute details; a leadership which meant speaking what he thought was the truth today and taking it back tomorrow if necessary. His leadership showed no cant in righteousness, no pedantry in scholarship, no pretension in friendship. He is a man who has grown by the responsibilities placed upon him—the burden of S.A.E. work. He put his powers out at interest and reaped usury in kind. His praise for the members of the Section at each meeting has helped each of us to come through with better and steadier work. He found no antidote for personal worry, and we all know that he had personal worry to match that of hard work at important tasks which burdened his mind beyond the ordinary views of personal worry.

Growth of the Society

THE accompanying chart, showing the increase of members on the rolls of the Society since 1909, indicates the growing appreciation of the value of the work done by the Society. It also reflects the work of the Membership Committee in bringing the Society's activities to the attention of the engineers and executives of the industry. The activities of the Sections also have been largely responsible for the increase in Society membership.



The rate of increase has been almost constant during the 18 years. The drop in 1921 was due to adverse industrial conditions.

Proposed New Form for Transactions

UPON recommendation of the Publication Committee, of which John Younger, of Ohio State University, is chairman, the Council is considering the publication of future Parts of TRANSACTIONS in the same page-form as THE JOURNAL. The over-all dimensions contemplated for TRANSACTIONS are 8½ x 10½ in., the present dimensions of THE JOURNAL, 8¾ x 11½ in., to be continued. The smaller size of TRANSACTIONS would be made possible by dropping three type-lines from THE JOURNAL page and having narrower margins.

The proposed form for TRANSACTIONS will make it possible to use the same page make-up as in THE JOURNAL and will save some expense and considerable time in the issuing of TRANSACTIONS. The Committee hopes that in the near future each Part of TRANSACTIONS can be issued within 3 months after the close of the period covered by it. It is expected that final action on the proposal will not be taken by the Council until the Summer Meeting at Quebec. Criticism of the proposal, or any suggestion in connection with publication of TRANSACTIONS, will be appreciated by the Publication Committee and the Council.

Military Mechanization

By A. W. Herrington[1]

NEXT month will mark the beginning of a military operation in which it is the patriotic duty of the automotive industry to cooperate with the Army. It is the first official opportunity afforded within the last decade for the industry to avail itself of the privilege of studying the military-transport equipment needs for all branches of the Service.

Ten years have elapsed since we emerged from the maelstrom of the World War. The automotive industry has progressed greatly within that period. Our military leaders have had time to digest, to discuss, and to formulate tentative policies pertaining to the use of all classes of mechanical devices by our Army. These studies have resulted in a determination to test the more modern mechanical equipment now available under actual field-service conditions.

The automobile, the motorcycle, the motor-truck, the tractor, the tank, and the airplane are items of equipment which the Army will always obtain from our industry, in moderate quantities in time of peace, but to the limit of our productive capacity in time of need. In compliance with the instructions of our progressive Chief of Staff, General Charles P. Summerall, a test of such equipment will be held at Camp Meade, Md., starting in July. The operation will be under the command of the commanding general of the Third Corps Area.

An effort will be made to determine the basic principles governing the mechanization of our military forces by practical tests in tactical and strategical employment of both equipment and organizations. Operations will be held over terrain sufficiently varied and difficult, and under all conditions of weather, to determine the limits of mobility of the various classes of vehicle. Comparisons will be made between motor-driven and animal-drawn equipment. It is hoped that it will be possible to obtain for this purpose at least a limited supply of motor-transport equipment of recent design.

War Automotive Equipment Depleted

The war surplus of motor equipment with which our Army was surfeited is rapidly becoming depleted. Within the next year a program of replacement of all classes of equipment will be undertaken. The results of this test operation will be used to determine types, specifications and performance requirements of military motor-transport equipment.

Invitations are being issued by the chiefs of the Army supply branches to all manufacturers whose products are susceptible of military employment. If any company is interested and has not received such an invitation, an inquiry addressed to the Quartermaster General of the Army, Washington, will bring a prompt reply.

An opportunity will be afforded to study the requirements of the infantry, the field artillery, the coast artillery, the cavalry, the Corps of Engineers, the Signal Corps, the Air Corps, the Medical Corps, the Ordnance Department, and the Quartermaster Corps. Detachments of personnel from each of these services are undergoing special training at present preparatory to the maneuvers.

In view of the accessibility of the test location, it is hoped that all manufacturers will avail themselves of the opportunity to send representatives of their engineering departments to observe these trials. Undoubtedly many among the younger engineering executives of the industry have had actual field experience in the American Expeditionary Force. Such experience will be found invaluable for a sympathetic comprehension of the equipment problems with which the military authorities are confronted. When the United States entered the World War, it could be noted that the civilian engineers whose opinions were at the greatest variance with those of the military authorities were those who had never observed, or who chose deliberately to ignore, the recorded experience of the Mexican Border operation in 1916.

Military men realize that in any future emergency full reliance must be placed upon those types of motor equipment that are immediately available from commercial production. The A. E. F. experience, tempered by 10 years of sober consideration, has brought the military mind to a fuller and more complete understanding of the automotive industry and of the adaptability of its products to military use. The Secretary of War has, as a component part of his office, a group of officers whose duty it is to keep fully abreast of the latest developments in industry. The mere recording of this progress is not sufficient, hence this decision to hold actual field-tests that the more intangible progress in improvement of mobility and durability of the various items of equipment may be properly evaluated.

Aside from any consideration of possible pecuniary profit or education, there exists in the interest of preparedness a patriotic duty on the part of the automotive industry to support and attend these maneuvers. In view of the active part which the Society of Automotive Engineers took during the World War, it is hoped that the visiting list at Camp Meade will show the attendance of a representative gathering from our Society.

The Army will welcome the advice of the engineering mind in its attempt to formulate a proper transportation policy for the future. The issue is rather sharply drawn. One school of thought maintains that in the future the movement of troops and materials must depend upon self-propelled vehicles. The opposite viewpoint is that conditions of terrain and climate will be such that self-propelled vehicles are not sufficiently mobile and that the older means of transportation cannot safely be abandoned.

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Independently Sprung Front Wheels a Remedy for Shimmy

By D. Sensaud de Lavaud[1]

Annual Meeting Paper — *Illustrated with* Diagrams and Photograph

THIS paper is an attack on the usual system of front suspension of an automobile and a proposal to substitute independently sprung front wheels for the conventional assembly of wheels, rigid axle and semi-elliptical springs.

Mounting of the front wheels on a solid axle is a survival of horse-drawn-vehicle days and is asserted by the author to be so unsatisfactory from the standpoint of rational mechanics that it should long ago have become a memory in the automotive industry. To the complex actions and reactions of the axle, oscillating between the springs and the tires, and of the wheels, with their gyroscopic effects, are attributed the phenomena of shimmy and wabble that have become so disconcerting and even dangerous since the advent of low-pressure tires and front-wheel brakes.

The origins of the various abnormal vibrations are analyzed, the effects of damping and of friction are discussed, and the part played by the conventional steering-gear and steering connections is considered. A distinction is drawn between damping and friction; the stabilizing effect of rake of the steering pivot and of deformation of the tires is explained; and the ineffective part played by friction shock-absorbers and by interleaf friction in the springs is described.

Rigidity and irreversibility of the steering mechanism are said to be most likely to induce shimmy at normal speeds with balloon tires and front-wheel brakes; hence the author advocates increasing the reversibility to the fullest practical extent and making the steering linkage sufficiently elastic.

The only specific remedy for abnormal front-end vibrations is, the author asserts, the adoption of correct independence of the front wheels, and he shows and describes a design that he has developed for such a construction.

He does not regard a similar independent suspension for the rear wheels as very desirable, but if such a suspension is to be used, he thinks it is better to adopt a split rear axle.

WHEN the first gasoline engine was put on wheels, certain features directly derived from horse-drawn vehicles were retained, and many of these features have been continued without change. Among them is one which is particularly deplorable, although its defects were hardly noticed at first and have been made to stand out only as the speed of automobiles has increased and as the desire for comfort has grown. I refer to the usual practice of mounting the two front wheels of an automobile on a solid axle, while leaving each one free for the necessary movement for turning the car.

If pains are taken to analyze the conditions under which such an arrangement must work in the normal operation of a motor-vehicle, it appears so unsatisfactory, from the strict standpoint of rational mechanics, that it should long ago have become nothing more than a memory in the automotive industry. The various and serious inconveniences which are the inevitable consequence of such an arrangement have not, up to the present, been attributed to their real cause. For this reason attempts have been made to lessen the trouble, rather than to abolish it, by empirical remedies which generally have only added other incorrect principles.

To summarize, my paper is really an attack on the usual system of front suspension of an automobile. Studying the matter from a scientific standpoint, I hope that you will conclude with me that this system should be condemned without appeal.

Unfortunately, it is impossible to analyze critically the various phenomena, at times very disconcerting, which are induced by the usual system of front suspension, without entering into arduous and delicate analysis and rational mechanics. It is my intention, however, to pass by practically all the formulas and mathematical developments and to offer only general ideas, the origins of the phenomena, and the conclusions of the long experiments I have devoted to this important question. All the theoretical proofs of these principles are reviewed in two communications I have made to the French Academy of Sciences.

Summarizing, it may be stated that the usual system of front suspension represents such a defective mechanical element wholly because it allows the rotating wheels to put into play gyroscopic effects that are always violent and dangerous.

I shall first show how these intervene in the abnormal vibrations at the front end of a car. These vibrations can attain a dangerous violence either by reason of a resonance which results in wabble or shimmy, or by reason of vibrational instability due to gyroscopic excitation.

I shall indicate, after this, the way in which these gyroscopic reactions permanently hamper the steering of the car and reduce its stability.

Finally, I shall place in its proper light the problem of front suspension by independent wheels. If there is a tendency at present to recognize the undoubted interest in such a system, the real motives have not yet been discerned. This is one of the chief causes of tinkering and uncertainty, whereas the path of progress is, in reality, marked out clearly and brilliantly.

1—ABNORMAL VIBRATIONS OF FRONT END

Experience has shown that the abnormal vibrations of the front end of a car are characterized particularly by a distinct oscillation of the axle between the springs

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and the tires, around a longitudinal axis. At the same time the two front wheels are affected by a conjugate flapping motion around their pivots, and this transmits alternate rotations to the steering-wheel and causes the car to advance in a series of elongated zigzags, easily recognized by the traces of the wheels on the ground. The intensity of this phenomenon is sometimes sufficient to set up violent bouncing of the front wheels on the ground in a frantic rhythmic dance. Under these conditions, it soon becomes dangerous or even impossible to drive the car.

Other movements are superposed: a translatory movement of the axle; rolling, pitching, and galloping of the chassis. These are parasites; they are secondary and do not appreciably interfere with the fundamental movements. The analysis should, therefore, be directed toward the natural and forced oscillations of the front-axle assembly around a longitudinal axis through its center of gravity. The conclusions are so definite that they explain completely the results of observations which have often proved puzzling and apparently incoherent.

The common type of front axle constitutes a double oscillator, having freedom of movement of two kinds. One of these corresponds to the oscillations of the whole of the axle and of the wheels between the tires and the springs. The other utilizes the ability of the wheels to oscillate around their pivots, thus rotating the steering-wheel by reason of the reversibility of the steering connections. In addition, the individual oscillators, the axle and wheels, react one on the other by gyroscopic reaction, as it is impossible for one to move without carrying the other with it.

We thus have the case of a double oscillator with reciprocal reactions. In reality, if the analysis is quite rigorous, it is a triple oscillator, with three kinds of freedom which must be studied, the constitutive elements of which are the axle, the wheels, and the chassis. The last mentioned, by reason of its roll due to alternative centrifugal forces, reacts on the axle through the intermediary of the springs. As the mass of the loaded chassis is very considerable, compared with that of the front-axle assembly, it can be argued with sufficient exactness that the chassis possesses relative immobility. In making my calculations upon the whole subject, I have, indeed, proved that this hypothesis is correct. As a consequence of this, we are required only to consider the two fundamental kinds or degrees of liberty of the front axle.

The Three Gyroscopic Couples

If the axis of rotation of a revolving body is subject to a simple movement, nothing more happens than if the body is immobile. The conditions are quite different, however, when the axis of rotation has an angular movement. There is then set up a gyroscopic couple which is proportional to the angular speed of the body, to that of angular movement of its axis, and to the moment of inertia of the body with respect to its axis of rotation.

As the wheel constitutes a revolving solid turning rapidly around its axis, it is seen that when the front end oscillates three simultaneous deviations induce the three fundamental gyroscopic couples:

(1) Deviation of the axle produces conjugated precessions of the front wheels around their knuckle pivots

(2) Deviation resulting from this common precession results in a resisting couple opposing oscillation of the axle

(3) The third deviation resulting from the gyrations of the vehicle as a whole in its zigzag movement gives rise to a gyroscopic couple acting on the axle

The first gyroscopic couple, due to the deviation of the axle and proportional to its speed, vanishes when the axle attains its extreme positions and the speed is zero. At this moment the periodic precession of the wheels is not accelerated, so that its speed is at maximum. The two wheels pass around their pivots at the same time into a position of equilibrium. As at this moment the elasticity of the steering-gear is null, the influence of its elasticity does not in any way modify this conclusion. In the same way, the wheels attain their greatest amplitude of precession each time the axle becomes horizontal. The movements of the axle and the wheels around their pivots thus become offset, the amplitude of one motion being proportional to the speed of the other.

It results that the first two gyroscopic couples, of which one acts on both wheels and the other on the axle, while apparently proportional to the speed, are in reality proportional to the displacement of the part on which they act. Acting thus as elastic reactions, they have a direct influence on the periods of natural vibrations. At each instant, moreover, they transmit energy from the wheels to the axle and vice versa, conjugating the flapping of the wheels without the necessity of causing the tie-rod or the knuckle-pin angle to play a part.

The third gyroscopic couple, which sets up a movement of the entire vehicle, does not act at all in the same manner. If it is noted that the angular speed of gyration of the vehicle is proportional to the locking angle of the wheels, it may be concluded that the gyroscopic couple of vehicular movements, acting on the oscillations of the axle, varies as the speed of its displacement. It is known that under these conditions it does not affect the periods of natural vibrations, which must be arrived at without it. Analytically, it acts as a damper, by an exponential multiplying the amplitudes the coefficient of which may be positive.

This observation is important, for it indicates that the zigzag movement of the car intervenes directly in the stability of the vibrations, and that it can not only destroy the damping effect but provoke violent excitation. Its rôle in this respect is essential and explains very clearly the abnormal vibrationary phenomena which hypotheses of resonance cannot elucidate.

Principal Vibrations

Any natural vibration of an oscillating system having reciprocal reactions results from the superposition of simple vibrations, called principal vibrations, equal in number to the degrees of freedom. Each principal vibration may be obtained separately if the initial displacements of the oscillators are in fixed proportions with one of them. There are as many series of these proportions as there are principal vibrations and degrees of freedom, the various oscillators then vibrating with the same period, which is one of the principal periods. When gyroscopic forces exist, as is the case here, the phases of the various movements are not in concordance.

Generally, when the initial conditions necessary to obtain a single principal vibration are not respected, and this is the case when the natural vibration is set up accidentally, an apparently very complex movement is set up, but this, in reality, only superposes the principal vibrations. A simple example will explain this somewhat abstract idea.

A ball oscillating at the extremity of a wire constitutes an ordinary pendulum. There is one degree of freedom, and therefore one period of oscillation, whatever may be the starting point. This is evident and well known.

Suppose a second pendulum is attached below the first one. We have then obtained two degrees of freedom, with two oscillators having reciprocal reactions, since one cannot move without carrying the other along. There now exist two principal and distinct vibrations, each characterized by a fixed ratio of the initial amplitudes. If the pendulums are put into motion at one of these ratios, the two will oscillate together with a simple movement having a common period, which will be the principal period.

One very important fact found in this problem should be noted. The ratio of the amplitudes is positive for the principal vibration and negative for the other. In other words, suppose that when releasing the pendulum the upper pendulum is always left in the same position. The lower pendulum will have to be directed to one side of the vertical for a principal vibration and to the other side for the secondary vibration. This observation is of primary importance and will be referred to later.

It is possible to generalize by attaching n pendulums in series one below the other. To the n degrees of freedom there correspond n principal vibrations, the periods of which are all distinct. If we abolish one pendulum, the n-1 new periods are all comprised between the old ones.

The case of the front axle and wheels is of exactly the same nature. The visible rôle of the wires, constituting the connections between the pendulums, is maintained here by invisible gyroscopic forces, which, however, have the same precision. The axle is one of the pendulums and the wheels the other.

The front-axle assembly, which is a double oscillator with two degrees of freedom, possesses two distinct principal vibrations which may be superimposed without interference. When the axle passes through its median position, one of the front wheels is at its extreme position to the right and the other in its extreme position to the left. This observation is fundamental. Each time the vibrations are set up naturally, the two principal vibrations will exist simultaneously, but as soon as they have to intervene, the selection will take place exactly as if each set of vibrations were separate. This is evident, for there is no mutual interference.

The principal periods, calculated without taking account of the damping and friction action, are the roots of an equation of the second degree containing symmetrically the imaginary individual periods Te and Tr of the axle and the wheels taken separately, by suppressing either the freedom of the wheels or that of the axle. These two periods are always comprised between the two principal periods which, in consequence, enclose them.

One principal period is generally very near Te and the other near Tr. In one case it is the axle which vibrates most, and in the other case it is the wheels. Moreover, if the periods of the axle and the wheels vary, together or separately, the principal periods, while never equal, evolve in a continuous manner, one successively approaching Te and Tr, while the other is contrary. This continuous change is a characteristic of principal vibrations and is met with in dealing with phenomena of resonance.

The period Te depends chiefly on the weight of the wheels and the elasticity of the tires. Roughly, it has been doubled by the adoption of low-pressure tires and front-wheel brakes. The period Tr is a function of the weight of the wheels, of the distance between steering pivot and the center plane of the wheel, of the value of the pivot angle, of the elasticity of the steering linkage, of the reduction ratio of the steering-gear and of its degree of reversibility. This period evidently increases with the weight of the wheels, the distance between steering pivot and the center plane of the wheel, the elasticity of the steering-gear, its reversibility, its gear reduction and the lightness with which the wheel is held by the driver. Finally, it is strictly dependent on the pivot angle, diminishing as the angle is increased and as the speed of the car is increased.

Stability of Principal Vibrations

The first fundamental problem in connection with principal vibrations is the study of their *stability*. It is a question which has not been raised up to now, for it is not one which strikes one at first sight; all the vibrations usually observed damp themselves out very rapidly if their oscilation is not sustained. However, the free oscillations of the front axle may sometimes, under the influence of the zigzag motion of the car, become greater and greater instead of damping themselves, notwithstanding the natural damping and friction, without any outside agency maintaining them.

The mathematical analysis of this curious phenomenon is, one must admit, rather a delicate matter, but with a little reflection the results become almost evident without the help of any formula.

The gyroscopic couple, due to the alternating gyratory motion of the car in its sinuous movement, is, as I have stated, in proportion to the deviation of the front wheels round their pivots. It is therefore in different directions for the two principal vibrations, since, with the axle in the same position, the wheels are locked to one side for one vibration and to the other side for the other vibration. There is no objection to reasoning as if the principal vibrations existed separately, since they are superimposed without interference. That, indeed, is the direct consequence of the fact that the simultaneous differential equations of the movement are linear. The gyroscopic couple of propulsion, which affects the axle, changes in direction as the side to which the wheels are locked changes, and it is thus necessarily transmitting energy for one principal vibration and resisting for the next. One vibration will be continuously excited, while the other will be damped. This forced damping will only superimpose its effect on that of the natural damping and friction.

Calculation shows that the vibration which will be excited is always that of higher frequency; that is to say, that possessing the faster rhythm. The successive amplitudes of the axle and of the wheels are, for each of the two vibrations, multiplied by an exponential factor, for which the coefficient of time is negative as regards the lower frequency vibration and positive for

the other. In such a case it is the factor of excitation which increases slightly more rapidly than the cube of the forward speed and in inverse proportion to the difference of the squares of the principal frequencies.

It is then evident that if the axle, after a precession, moves in any manner whatsoever, the gyroscopic couples will at first superimpose themselves without interfering with each other in any way. That of lower frequency diminishes at once and disappears, the other, on the contrary, has a tendency to grow greater and greater without interruption. An immediate and automatic selection has taken place; only one principal vibration persists after a very short time. It can then increase very fast and in a manner which must quickly make it dangerous if the exciting action is greater than the natural damping action and the constant friction of the shock-absorbers.

I must now define very clearly the circumstances under which such a possibility exists by examining in succession the parts played by the *damping* and *friction*. It is desirable, but often neglected, to make a distinction between friction and damping, which do not both act in quite the same manner.

A *frictional* resistance is constant, opposed to the displacement speed which causes it and altering its direction in conformity with it. A *damping* resistance is proportional to the speed of displacement. On the one hand, there is the damping effect on the axle due chiefly to the deformation of the tires. On the other hand, the front wheels, in their motion round the pivots, are damped as a result of the rake of the steering pivot. Indeed, when entering a curve, the center of gravity of the vehicle is subjected transversely to a centrifugal force which is proportional to the locking angle of the front wheels as well as to a force of inertia which varies according to the speed of the locking of the wheels. The latter is the cause of lateral reactions on the road surface which have a damping quality around the pivots.

Both the axles and wheels thus possess individual damping factors. It can be shown that each intervenes separately for a principal vibration with very little interference on the second. A gyroscopic excitation is shown by analysis to manifest itself as a negative damping. The damping factor of the excited vibration has simply to be deducted from that of the excitation. If the higher vibration frequency is in close relation to that of the wheels on their pivots, the strong damping effect on the wheels will overcome excitation, provided the rake is sufficient, and stability will be the rule.

However, this corresponds with a steering-gear possessing little elasticity and is decidedly unfavorable as regards shimmy when low-pressure tires and front-wheel brakes are adopted, as I shall show later. When, on the contrary, the highest frequency of vibration is very similar to that of the axle, instability will become possible at a certain speed, immediately the factor of excitation, which increases rapidly with the speed, becomes greater than the damping factor. One must not forget that, under these conditions, with low-pressure tires and front-wheel brakes which reduce by one-half the frequency of induced vibrations, all other conditions remaining as before, the factor of excitation will have become three or four times as great. The self-excitation of vibrations is therefore likely to be mistaken for a direct consequence of the adoption of low-pressure tires and front-wheel brakes.

It remains for me, in order to elucidate the sequence of the phenomena brought into play, to determine the part played by *friction* and represented almost entirely by the action of the shock-absorbers of the usual friction type and, in a lesser degree, by the rubbing of the spring leaves on one another.

By analysis, I have demonstrated that, so long as the initial amplitude of the axle vibration remains below a certain limit, which will be higher as the shock-absorbers are adjusted more tightly, the successive oscillations of the axle and wheels are reduced, even when a state of self-excitation has been reached. But it is sufficient for the initial amplitude to exceed this extreme value, for any reason, to render the shock-absorbers powerless. The successive oscillations of the axle and wheels are, at the same time, increased, a little less rapidly however than if there were no friction. The principal vibration induced is then unstable; the successive amplitudes grow spontaneously in a manner which very rapidly becomes dangerous. What precedes calls attention to the fact that powerful damping alone is capable of preventing instability from manifesting itself at usual speeds.

On the contrary, friction shock-absorbers do not act to prevent as regards the possibility of the phenomenon; they merely serve to make its appearance less likely. In other words, the instability of vibrations can always occur beyond a certain fixed speed whenever the damping is not sufficient to prevent the excitation factor from becoming greater than the damping factor. Still, for this instability to manifest itself, it is necessary in addition that the angular oscillation of the axle or of the wheels should reach an amplitude which will be greater in the same proportion as the damping device is tighter. In this respect it is important to note that frictional shock-absorbers, such as are generally fitted, are not mechanically correct fittings and that their effectiveness is always irregular.

It is a fact that when an axle is oscillating transversely it also has a parallel vibration. Shock-absorbers cannot simultaneously damp both movements; they act on one or the other but never on both at once. This drawback, which is very serious, is essentially due to the fact that their action is in no way dependent upon the rapidity of displacement of the friction discs; therefore, if the shock-absorbers damp an angular displacement, they produce a couple which has no resultant and the translatory movement takes place freely. If, on the contrary, they damp the translatory movement, they bring about a resultant without a couple and oscillation is free to act.

One may safely come to the conclusion that the action of the shock-absorbers on the angular oscillations of the axle are almost invariably discontinuous; there must therefore be certain critical moments when these oscillations are free to take up great amplitude.

Hydraulic shock-absorbers are quite different, for in their damping effect their action depends on the speed of their displacement. They are therefore constantly able to cope with beneficial effect with both the angular and the parallel vibrations. Unfortunately, although their adoption is a rational mechanical application, it is exceedingly difficult to keep them perfectly oil tight in service.

Finally, I would remark that one can consider that the gyroscopic excitement due to the zigzag movement of the car is productive of a suppression of damping as

regards the principal vibration possessing the highest frequency, and this action is greater in proportion as the car is traveling faster. Even in cases when the damping effect is greater, its effect is considerably diminished. This simple remark explains why a resonance of inexplicable intensity may, on investigation, prove to have an extremely small cause. It is due solely to the fact that it affects mechanism the damping of which is imperfect.

False Shimmy

I have given the appellation "false shimmy" to the manifestations of vibratory instability, as opposed to the shimmy which I define as a case of resonance. Invariably commencing at a certain fixed speed, it is sufficient for some outside cause to induce vibrations of sufficient amplitude for the succeeding oscillations to constantly continue increasing with an ever-increasing intensity. The violence and rapidity of this amplification are greater in proportion as the speed of the car is greater.

At the same time as the axle vibrates, the flapping of the wheels around their pivots causes the car to acquire a zigzag movement which constantly increases. Under these conditions, the steering of the car rapidly becomes very trying and indeed dangerous. If one increases the speed, the disturbance becomes uncontrollable; one must slow up, and steadiness will reappear as soon as damping is greater than excitation. The original speed may then be resumed and maintained just so long as a new outside cause does not reproduce an identical succession of phenomena. It is not a resonance and the balance of the wheels is not a factor in this case. An inequality in the road or several successive inequalities may induce instability, especially if the latter, in successive jerks, act in synchronism with the principal period. Unequal pressure in the tires may be a determining cause of disturbance.

The self-excitation of vibrations is also frequently the result of taking a sharp turn at high speed. It is evident that centrifugal force then tends to throw the car toward the outside of the curve, so that the two tires on the inside of the curve are slightly less flattened and the two on the outside are flattened a little more than when the car is running straight. Consequently, the front axle inclines itself, rising at the end at the inside of the curve. This inclination will be further increased by the superimposed effect of the gyroscopic couple, which acts on the front axle due to the precession imposed on the front wheels by the gyratory movement of the car.

I shall now explain how one can obviate the instability of the vibrations.

First, it will generally be impossible at normal speeds if the stiffness of the steering-gear and its irreversibility are sufficient for the frequency of the vibrations of the wheel itself to be considerably greater than that of the axle. The induced principal vibration of greater frequency will then be considerably damped if the steering rake is sufficiently large. Excitation cannot then get the upper hand at normal speeds and amplification will not take place. But, in the first place, such a condition is one of those most likely to induce shimmy at normal speeds with low-pressure tires and front-wheel braking. Secondly, rigidity and irreversibility are two factors which cause play in working parts in a very short time. Hence the initial conditions are no longer respected and one no longer eliminates the phenomenon he wishes to avoid.

It is far preferable, by separating as far as possible the two principal frequencies, to lessen the excitation factor, which is in directly inverse proportion to the difference between the squares of these frequencies. It is therefore necessary to do exactly the opposite of what I have previously said, by adopting, when low-pressure tires and front-wheel brakes are used, sufficiently elastic steering connection and fairly reversible steering. Logically, these two conditions should go hand in hand, as will be made fully evident.

Supporting the steering-gear arm on springs should be carefully studied. It is also advisable to increase the reversibility of the steering as much as is practical, even if this means adopting a very gentle-acting hydraulic shock-absorber which can easily be made oil tight. The vibration induced will, in such a case, possess a period very near that of the axle. Moreover, it is essential that the oscillations of the axle should be sufficiently damped. The use of rubber, such as is now obtainable, in the suspension is most beneficial. One can also use hydraulic or compound suspensions which are, by far, more correct mechanically. Please note also that the elasticity of the steering which I advocate is most favorable from all points of view, both in avoiding shimmy and increasing driving comfort.

The Two Critical Resonance Speeds

It is certain that the principal vibrations of the front assembly can be effected only by instability or by resonance. Having studied the first phenomenon, I shall proceed to analyze the second.

The disturbing action is due to a more or less pronounced but practically unavoidable lack of balance of the front wheels, and its period is that of one revolution of the wheel. No matter what respective positions the unbalanced parts of each wheel occupy, a disturbing couple is created acting on the wheels around their steering pivots, or a couple affecting the front axle, or both may co-exist.

As the words indicate, there is resonance just as soon as the duration of a complete revolution of the wheel coincides with a principal period, without taking friction or damping into account. When there is a state of resonance, vibratory energy attains a maximum but no amplitude as is often believed.

It is well to note that, contrary to what occurs in the case of self-excitation, resonance is an essentially stable phenomenon, capable of continuing indefinitely without decreasing or increasing so long as the corresponding critical speed is maintained. Whenever the speed is either below or above this critical speed, the manifestations die out and resonance disappears.

As the equation which enables us to ascertain the principal periods is of the second degree, there must necessarily be two critical speeds inducing resonance. The one, ω, is, as a rule, very close to the imaginary speed ω_e which causes resonance of the axle alone; this is the speed of shimmy. The other, ω_1, differs very little from the imaginary resonance speed ω_r of the wheels, considered independently, around their pivots; this is "waddling" speed. In the first case resonance seems to affect the axle more particularly and, in the other, it affects the wheels.

The two speeds, ω_e and ω_r, are easy to ascertain if

one knows the individual periods of the axle and wheels. The one, ω_e, is proportionately less as the wheels are heavier and the tires less inflated; this is why shimmy was never troublesome until the advent of low-pressure tires and front-wheel brakes. Lack of resiliency of the springs, unless it is excessive, has little influence but, once shimmying has started, tends to prevent the bouncing of the wheels. The second speed ω_r, is all the smaller when the wheels are heavier and farther removed from the steering pivots, when the steering angle is small, and especially when the steering is more elastic and more reversible.

The two values, ω_e and ω_r, which can easily be calculated individually, intervene symmetrically in the equation of critical speeds. Any modification in either or both provokes a continuous variation of the critical speeds without the two ever becoming equal. Thus, in a continuous manner, waddling may be transformed into shimmy, or shimmy into waddling. This transformation of critical speeds is a most important point and, in many cases when one meets with disconcerting results, is invaluable to explain them.

In all that precedes it is well to note that the importance of the two critical speeds depends not only on the characteristic points of the front-axle assembly but also on those of the steering-gear. If the steering rake remains within the usually adopted limits of 2 or 3 deg., the critical speeds will agree approximately with the laws of similarity, as set out below and which are fundamental.

(1) If ω_r is less than ω_e but remains proportionate, shimmy will be proportionate with and greater than ω_e, while waddling speed will be proportionate and less than ω_r. Under such conditions waddling will be noticed first, followed by shimmy. Such was the case usually on old cars fitted with high-pressure tires and no front-wheel brakes. Steering-gears having no play, that were fairly rigid and sufficiently irreversible, and in addition in case of need an increase in the angle of rake, as they tended to increase ω_r were sufficient to suppress waddle at normal speeds and, of course, to prevent shimmy. Thus there could be no perceptible critical regime

(2) If ω_r is greater than, and in proportion to ω_e, then the permutation of critical speeds, which is so much to be feared, has occurred. Shimmy speed remains proportionate with and *inferior* to ω_e, and waddling speed remains proportionate with and greater than ω_r. Shimmy, therefore, appears first, at normal speeds, and is sharp, violent and entirely unaffected by the steering rake. Waddling speed, which will as a rule be a very high speed, will, more often than not, be unattainable. The conditions enumerated above apply to the case of a fairly rigid steering-gear and a modern car fitted with low-pressure tires and front-wheel braking, the simultaneous adoption of which has reduced ω_e by one-half

It thus appears that the adoption of low-pressure tires and front-wheel braking has destroyed that mechanical harmony which can be reinstated only by diminishing ω_r relatively to ω_e. In other words, our new requirements are a more elastic and more reversible steering in consequence of the lower pressure of the tires and the greater weight of the wheels. We are then back to the original case of similitude. But we shall now be compelled to go through waddling at a speed which will be lower and lower as the suppleness and reversibility of the steering are greater. That is because, owing to speed ω_e being so low, waddling cannot be eliminated before it has been transformed into shimmy at normal speeds. Still, as a general rule, this waddle, considerably damped by the steering rake, will be barely noticeable.

Under these conditions, shimmy will occur only at very high speeds, more often than not beyond driving range. If such is not the case, however, it may be made more remote, and indeed eliminated altogether, by increasing the steering rake, which has a very pronounced influence on it when it constitutes the second critical speed. This increase should be limited so as not to induce objectionable waddling; for it must be remembered that, if the steering rake is increased, ω_r is also increased at the same time as waddling speed, and this has a tendency to increase the vibratory energy which is brought into play. On the other hand, the damping of the wheels becomes greater since it depends on the importance of the steering-rake angle, and it tends to moderate vibratory action.

These two factors act inversely; there is therefore an optimum range of rake of 2 to 3 deg. which will be higher in proportion as the wheels are heavier and the car lighter. The steering-rake angle is therefore confined within strict limits that should never be lost sight of. If one allows himself to depart from it to any extent, he finds waddling, originally negligible, becoming intense and degenerating into shimmy. This is what sometimes happens when a longitudinal change in the load of a car is sufficient, by inclining the chassis, to alter the steering rake to such an extent as to improve the facility for passing through the critical speeds.

Please note also that it is well to remove the pivots farther from the mean plane of the wheels, which tends to reduce ω_r. In cases where waddling manifests itself first, it occurs at lower speed and shimmy at higher speed. That is precisely the result we want to attain. I will refer later to this question of the position of the steering pivots.

As opposed to what happens in the phenomenon of vibratory instability, damping has no effect on the value of critical speeds; it diminishes its manifestations by increasing the range of resonance. In other words, when damping is more marked, the vibrations are less violent but last longer, both before and after the critical period of speed. It must also be remembered that the damping factor is diminished by the action of gyroscopic excitation and to an extent which increases with the speed of the car. This is a simple explanation of the intensity, which sometimes assumes surprising proportions, of the shimmy effect.

Again, if the usual frictional shock-absorbers are sufficiently tight, they may interfere with resonance by tending to make successive oscillations convergent. I have shown that any friction may act indifferently on either of the two principal vibrations, so that shock-absorbers may oppose themselves to the manifestation of waddling or shimmy without altering in the slightest the theoretical value of their speeds.

Unfortunately, as I have already pointed out, these parts act in an irregular way, for, as a rule, they only damp the angular oscillations of the axle in an intermittent manner.

It should be possible to adapt shock-absorbers so that they would be capable of functioning in two different ways separately, one on movements parallel with the axle, the other on its angular displacements.

Concerning the fact that any friction acts indifferently on either of the two principal vibrations, I would call attention to a curious fact. Cars which are not fitted with a differential are not, as a rule, subject either to shimmy or to waddle. What happens is that the moment the car starts a turning movement, the inside rear wheel begins to spin slightly or, failing that, increases its tangential driving grip on the road. The other rear wheel offers a resistance. The drive becomes unsymmetric and, thanks to the steering rake, the front wheels are brought into line by constant lateral reactions. They have the same effect as would be produced by friction of the wheels around their axles changing in direction according to their angular deviation. I have, on the other hand, studied and methodically experimented on a new differential which has no toothed gears and which presents exactly the same advantages.

I must now ask you to note that, since a vibration of resonance includes both forced vibration and superimposed natural vibration, vibratory instability undoubtedly can be induced by shimmy. In such cases it aggravates its intensity very considerably. When once one has got beyond the critical speed, false shimmy persists alone and can be suppressed only by slowing down.

Finally, the energy absorbed by shimmy, false shimmy or waddling must obviously be supplied by the engine. The front wheels take up an actual flapping movement on the road, which in turn develops in them periodic lateral impulses. These reactions, on an average road surface, have component forces the average value of which is related to time. Hence the origin of a supplementary resistance to propulsion, which absorbs power.

SUMMARY

The front assembly of a car of the ordinary type may be the location of two kinds of abnormal vibrations, either isolated or combined. The one is the result of vibratory instability, which may occur at any speed beyond a certain fixed limit and which grows constantly worse in proportion as the speed is increased. It is in no way dependent upon the lack of balance of the wheels. The other is a mere resonance due to the lack of balance of the wheels occurring only at certain absolutely fixed speeds and ceasing whenever the car is above or below those speeds. One or other of these phenomena is possible only because there are gyroscopic reactions between the wheels and the axle.

The only specific remedy, which should be adopted by all, is correct independence of the front wheels, which ensures absolute suppression of any periodic gyroscopic reaction. Moreover, it is impossible to continue to put up with the drawbacks of the abnormal vibrations of the usually adopted type of front assemblies.

The attainment of mechanical harmony demands imperiously that the steering shall be suitable to the use of low-pressure tires and front-wheel braking. It is desirable that it should be sufficiently elastic and reversible. Complete reversibility may even be favorable, provided the steering is fitted with a soft hydraulic damper free from leakage. If, on the other hand, it is necessary for the purpose of completely eliminating *shimmy*, one can have recourse to a setting out of the pivots and a moderate increase in the steering-rake angle. One should, however, be careful to maintain this angle within strict limits. It is very obvious, as regards waddle and shimmy, that it is well to balance the wheels as much as possible both statically and dynamically. Damping the oscillations of the front axle can only lessen shimmy, but it can absolutely eliminate the instability of vibration.

Frictional shock-absorbers may prevent waddle and shimmy, but their effectiveness can be absolute and constant only if they have independent means for preventing the parallel and angular movements of the axle. Friction, moreover, never makes it impossible for instability of the vibrations to exist, but the amplitude of the vibrations necessary to induce instability increases in proportion as the frictional shock-absorbers are made tighter. The use of rubber in the suspension affords a very rational form of damping.

Combined hydraulic and frictional shock-absorbers, properly studied out and regulated, also present undoubted interest, since friction and damping play very different parts, both of which are important.

It is certain that, when one learns to distinguish clearly between those two factors and to allocate them judiciously, he will have gained a partial control over the apparent capriciousness experienced up to the present in the vibratory manifestations of the front assemblies of our cars.

As you have been able to judge, this is a complex problem. It took me many months, and I had to use the most abstract mechanical knowledge, to clearly discern its various elements. It gives me great pleasure to impart the result of my investigations, and I shall be especially pleased if they help to guide you toward desirable solutions.

2—DISADVANTAGES OF FRONT-AXLE ASSEMBLY

I have been dealing with those abnormal inconveniences which may result from the use of the generally adopted type of front-axle assembly. I shall now review the constant inconveniences due, as in the former instances, to gyroscopic reactions. To determine the importance of these relations I shall indicate simple formulas which we can apply.

Owing to the fact that the two wheels are positively connected with a single axle, it necessarily follows that any rise or drop in either wheel, in relation to the other, must immediately determine a common deviation of

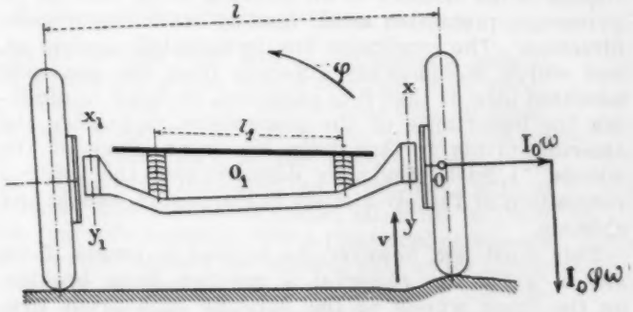

FIG. 1—DIAGRAM FOR ANALYSIS OF GYROSCOPIC REACTIONS OF CONVENTIONAL FRONT-ASSEMBLY

their stub axles and an inclination of the front axle itself. This movement exists continually whenever the car is running on uneven surfaces.

As I have remarked, a wheel, when it is rotating, constitutes dynamic mass rotating at great speed around its axis. So long as this axis is subject only to a movement following a plane, the conditions are the same as if the wheel were not revolving. The moment, however, there is the slightest deviation, violent gyroscopic precessions are set up.

Let us assume that the wheels and front axle are inclined transversely with an angular speed of φ, for instance because the front wheel, on the driver's left, is raised by an obstacle. Let I_o be the moment of inertia, in relation to its axis, of a wheel fitted with a brake drum and possessing an angular speed of ω. The positive direction of the rotation being from right to left, its kinetic moment is $I_o\omega$, following a line passing along its axis as shown in Fig. 1. The inclination of the front axle causes a deviation of this kinetic moment, the extremity of which, in the neighborhood of the top, assumes a speed of $I_o\varphi\omega$.

Résal's theorem shows that the moment of the resulting gyroscopic force is equal, and in the opposite direction, to this speed; hence its direction is downward, as shown, and its value, which is the same for each wheel, is $G=I_o\varphi\omega$. It follows that, if the front wheel on the driver's left is caused to rise over an obstacle, both front wheels are simultaneously subjected to a gyroscopic precession which tends to cause them to lock around their steering pivots from the left to the right of the driver. This effect is absolutely independent of the distance between the steering pivots and the mean plane of the wheels; its unavoidable manifestation is the reason to which we must look to account for the origin of the repeated knocks and jerks one feels at the steering-wheel when traveling on a rough road and which one endeavors to damp to a certain extent by fitting an irreversible steering-gear.

It will be well to note here that the forces resulting from the gyroscopic effects act inversely to the forces induced around the steering pivot by the tangential precession which the wheel receives when it meets an obstacle. It is a common error to ascribe to those road shocks the intensity of the reactions one feels, when, in reality, those road shocks have a damping, and generally very small, effect in relation to the gyroscopic forces.

In the case under examination it must be obvious that contact with the obstacle will tend to make the left wheel turn from right to left with a strength proportionate to the distance of the steering pivot, whereas its gyroscopic precession would tend to act in an opposite direction. The conclusion one immediately arrives at, and which is somewhat different from the generally admitted idea, is that it is expedient, in order to diminish the importance of the precessions, to remove the steering pivots farther from the mean plane of the wheels. I have previously demonstrated that such a disposition of the pivot tends to counteract wabble and shimmy.

This must not, however, be carried to excess if we are to avoid too powerful a reaction from braking on the front wheels or the bursting of a front tire. The dogma of the necessity for the convergence at the point of contact with the ground of the centers of the steering pivots with the mean planes of the wheels has therefore no sound foundation in fact, as I have been able to ascertain to my own satisfaction.

It is certain that, with the steering pivots far from the mean planes of the wheels, the steering is harder at low speeds whenever the lock causes the front wheels to turn in opposite directions round their axles, for instance when moving the car in a garage. This drawback disappears, however, when the speed is sufficient to avoid an inversion of speeds occurring.

To appreciate the importance of the gyroscopic reactions let:

p = the weight of a wheel and its brake drum
R = its outside radius
ρ = its gyration radius relatively to its axle
$V = \omega R$, its forward speed
l = the tread of the car
$v = l\varphi$, the speed of the rise of one wheel as compared with the other wheel
g = 9.80 m. (32.16 ft.) per sec. per sec. acceleration due to gravity

If we replace I_o by $\frac{p}{g}\rho^2$, we find that the gyroscopic couple can be expressed simply:

$$G = \frac{p}{g}\cdot\frac{\rho^2}{Rl}Vv \qquad (1)$$

It is therefore proportionate to the forward speed multiplied by the rising speed. The extents of the movements have no effect whatsoever, but only their rapidity. Making the wheels lighter and carrying their weight as near as possible to their centers have a beneficial influence.

If $p = 30$ K_o, $R = 0.40$ m., $\rho = 0.25$ m., $l = 1.40$ m., $V = 25$ m-sec., or 90 km-hr., $v = 5$ m-sec., we find $G = 42.5$ kg-m. (307.4 ft-lb.).

As the turning action on both wheels around their steering pivots is identical, we find a total gyroscopic procession aggregating $2G = 85$ kg-m., which will be transmitted to the steering-gear, assuming the steering pivots to be parallel to the mean plane of the wheels. Assuming the steering-gear to be rigid and irreversible, with, for the sake of argument, a gearing of 7 to 1, the reaction couple at the steering-wheel would be 12 kg-m., corresponding to a manual effort of 60 kg. (13.23 lb.) with a steering-wheel 400 mm. (15.748 in.) in diameter.

In practice, one could not hold the steering-wheel and it would move with a sharp jerk, particularly disagreeable and fatiguing owing to its repetition. One tries to obviate this by a more or less complete irreversibility of the steering-gear, which, of course, does not in any way modify the violence of the precession. With use, the steering-gear that is constantly subjected to jerks must necessarily become loose, and this further increases the precessions and vibrations.

As no steering mechanism can be perfectly rigid and no worm gears would be made absolutely irreversible, the front wheels, under the action of gyroscopic couples, assume, with the steering pivots as centers, a common movement of precession with an angular speed of ψ. This precession, which still further throws out the kinetic moment of each wheel, develops another gyroscopic couple, the moment of which, in a horizontal direction, assumes a value of $G_1 = I_o\psi\omega$. In the particular case I have taken as an example, the direction of this moment is toward the rear, as shown in Fig. 2. The total couple $2G_1$ which results therefore counteracts any deviation of the front axle and increases the pres-

sure on the ground of the wheel which is being raised by the obstacle. If, for instance, the value of ψ is in the neighborhood of 2, the surplus load thus created will not be more than 50 kg. if we take the previous figures.

In the foregoing I have not taken account of the subtractive couple resulting from the tangential percussion originating when the steering pivots do not coincide, at road level, with the mean plane of the wheels. With low-pressure tires it seems that, except under abnormal conditions, this effort is not likely to exceed 100 K_o. Assuming that the projection of the steering pivot to the road is 0.10 m. (3.937 in.) from the mean plane of the wheel, a couple amounting to 10 kg-m. will come in deduction of the sum of the two gyroscopic couples which have a tendency to lock the wheels over. In reality, these two effects are not absolutely simultaneous, but, at high speeds, the difference in their periods is not noticeable. One can, in any case, be sure that gyroscopic action preponderates by a great deal.

Moreover, the gyroscopic reactions are detrimental both to the pleasure of driving and to the wear of the working parts, and the combined wabble they constantly cause in the front wheels militates against roadability. Indeed, roadability is, primarily, directly dependent upon the steadiness of the front axle itself. In connection with this I have shown that the precession of the front wheels was likely to cause that sidewise floating movement of the rear which is so characteristic of a car that holds the road badly.

While on this subject I desire to make a reference to cars fitted with front-wheel drive. One usually dilates upon the remarkable steadiness and roadability of such cars. One should note that front-wheel drive is, in principle, associated with independent front wheels. It is precisely that independence, and not the fact that the drive is at the front, which gives these unquestionable advantages which have been verified. My personal opinion is that, apart from a few practical and secondary advantages, the front-wheel drive does not, in itself, produce any real technical benefit.

Such is, in a few words, the capital and constant defect of the more commonly adopted type of front steering-gear. It is as unavoidable as it is unpleasant, and it can be overcome only by radically eliminating this most unsuitable disposition. Here again, therefore, proper independence of the front wheels imposes itself imperiously. It improves both the roadability and the comfort of driving. The steering can be fully reversible without any noticeable reaction at the steering-wheel rim, even on the worst road.

Failing this solution, which is rational in every respect, it is a good thing to allow, by rule of thumb, a certain elasticity, without any play, to the steering-gear by means of the pendulum lever. The gyroscopic precessions will then damp themselves, considerably diminishing the jerks of the steering-wheel and affording better wear of the working parts. As I have shown, this simple palliative may also make it possible to avoid the disastrous manifestations of shimmy. The wabble of the wheels thus set up by their precession is rapidly damped by the pivot angle, the damping effect of which should never be lost sight of.

Again, in addition to the capital drawback, a conventional front axle presents many others, much less important, which so far have not been taken into consideration. For one thing, the unsprung weight is that of the whole of the front gear. When the two

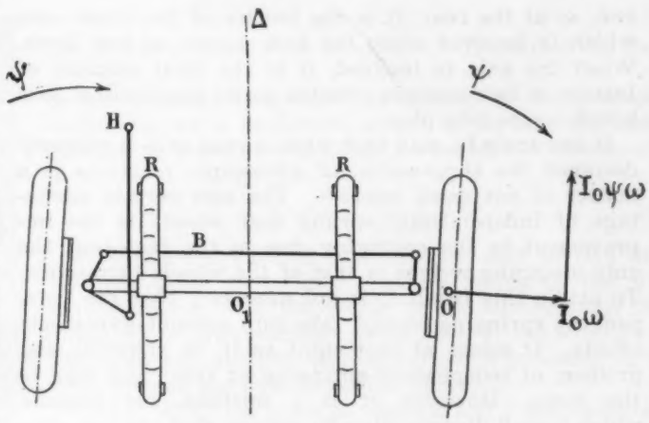

FIG. 2—DIAGRAM FOR ANALYSIS OF PRECESSION OF FRONT WHEELS

wheels wabble in unison they are subject to a resistance due to the inertia of that mass. Also, when the front axle is inclined, the inertia of the whole of the front gear comes into play in relation to the longitudinal axis of its center of gravity. Hence, in either case, the wear of the tires is increased and there is a certain amount of retardation in the spring action.

With independent front wheels, the unsprung weight is limited to that of the wheel; all other conditions being identical, the springing is improved. On the other hand, when the front axle is inclined, as the result of a wheel clearing an obstacle, the tire surface in contact with the road tends to move laterally; and, although the elasticity of the tread comes into play, still there is an extra cause of wear, small perhaps, but continually repeated.

Moreover, the springs are subject to torsional strains since, at their point of contact with the front axle, the latter is subject to a rotational movement. One must note also that, if the front ends of the springs are fixed, the displacement of the front axle may cause reactions in the steering-wheel or wabble of the front wheels quite independently of gyroscopic reactions. In this case, as the drag-link has its fixed point at *H*, to the rear, as in Fig. 2, the connections are incompatible and the wheels have a tendency to lock over when the front axle rises or drops. They may thus set up a kind of wabble, under certain conditions, which has no connection with the real wabble but may superimpose, acting as a parasite. This may be dealt with satisfactorily by making the rear end of the spring the fixed end. This arrangement is being adopted more and more.

GYROSCOPIC REACTIONS OF REAR OF CAR

It must be obvious that, with a conventional axle at the rear, gyroscopic action should manifest itself there, but the consequences are far less serious than in front.

If the rear wheel on the left of the driver rises on meeting an obstacle, each of the wheels receives the gyroscopic couple *G*, measured as previously, with a vertical axis. The precession couple 2*G* tends to force the whole rear-axle assembly into a rotational movement from left to right around the vertical axis of its center of gravity, but this movement is prevented by the connections of the springs, the driveshaft, and sometimes by triangular stays of a special type which make the assembly more rigid. As was the case with the front

end, so at the rear, it is the inertia of the whole axle which is involved when the axle moves up and down. When the axle is inclined, it is the total moment of inertia of this mass in relation to its longitudinal axis which comes into play.

It can truly be said that when a rear axle is properly designed the suppression of gyroscopic reactions is a matter of but small interest. The only certain advantage of independently sprung rear wheels is the improvement in the springing due to the fact that the only unsprung weight is that of the wheels themselves. To attain this result it is not necessary that the independent springing should take into account gyroscopic effects. It seems at first sight as if, in principle, the problem of independent springing at front and rear is the same. However, it is a mistake, for reasons which I shall discuss later, to assume that one can simply transfer to the rear a system which is correct in front. This common and unsatisfactory generalization is due, in a great measure, to the fact that the problem of independently sprung wheels has not been studied in its true light as I have endeavored to present it herein.

One must not lose sight of the fact that the most imperative obligation is the suppression of gyroscopic reactions in the front assembly. The question of the improvement of the springing, thanks to the reduction in the unsprung weight, is of far less importance. It should be considered only as a very secondary matter.

3—INDEPENDENTLY SPRUNG WHEELS

Speaking in the most general way, two wheels are independently sprung if the free displacement of one compels no movement of any sort in the other. The connection between each wheel and the chassis must be elastic in a vertical direction but without the possibility of any lateral displacement. This definition is incomplete, for independently sprung wheels might conform with this rather vague definition without possessing the principal and most important advantage; namely, the suppression of gyroscopic reactions.

I would add, therefore, that independent springing is correct if it achieves the suppression of gyroscopic reactions, this additional condition being an imperative necessity insofar as the front wheels are concerned.

Whatever its movements, a wheel must turn around an axis parallel to its kinetic moment, that is to say, parallel to its rotational axis. As the kinetic moment, under all conditions when the wheels move freely, reduces itself to a displacement, the gyroscopic movements are null. If, by using a slide or by adopting levers, one limits the wheel to a strictly vertical displacement, it merely constitutes a special case to which one is not compelled to conform in the definition of correct independent springing. This particular case simply corresponds to a rotation around a fixed axis of infinity. It is quite obvious that, when two wheels are thus independently sprung, no rigid transverse connection can be established between their centers. In consequence, it is impossible to couple them in the usual way by a tie-rod as shown at *B*, in Fig. 2. The fact of one wheel rising in relation to the other would cause a deformation of the articulated parallelogram and the two wheels would have a tendency to lock in opposite directions. This might be overcome to a certain extent by careful spring compensation of the connection, but such a system would not be rational.

Independently sprung front wheels therefore almost imperiously call for double steering-control, each wheel being independently controlled. This is the only real solution. Special care should be given to the establishment of the connections so that the free movement of the wheels cannot, in any case, cause any noticeable reaction in the steering-gear, otherwise a wheel might lock over through rising or dropping. Moreover, I regard it as desirable to allow a certain elasticity in each control, in the drag-link arm. For one thing, the steering is more smooth, and on the other hand, even assuming that the locking of the two wheels is not strictly in accordance with theory, the two wheels, in practice, lock properly, thanks to the cant of the front axle and to their respective elasticity.

Independently controlled front wheels undoubtedly add an extra element of safety, for, should the control of one wheel give way, the car would still be easily controlled by the other wheel only. The cant of the axle automatically takes care of the combining of the lock of the two wheels.

Furthermore, front wheels fitted with correct independent springing should be controlled by a fully reversible steering-gear. Irreversibility of the steering is, in itself, a fault. It is a rough makeshift and a barbarous one which enables us to put up with the absolute imperfection of the customary front steering-assembly. There is no other excuse for its existence, and, especially, this method of damping gyroscopic precessions is detrimental to all of the working parts.

With front wheels correctly sprung independently and an entirely reversible steering control, no noticeable reaction exists at the steering-wheel rim, even when running over a very rough surface. The comfort

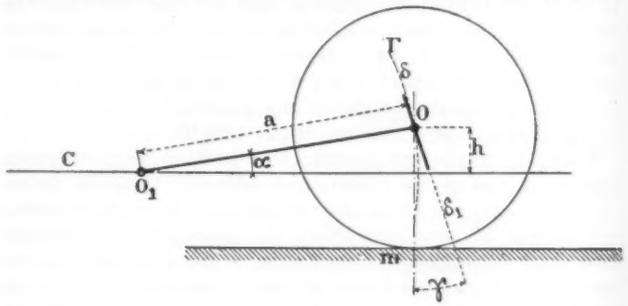

FIG. 3—DIAGRAM FOR ANALYSIS OF EFFECT OF VARIATIONS OF STEERING-PIVOT ANGLE

of driving undoubtedly is greater; ease of control is greater, and the steering is absolutely steady, thanks to the cant of the front axle. The driver has constantly the feeling that he can sense the balance of his car far better.

As regards the relative advantages of the various methods adopted for the fitting of independently sprung wheels, there is not the slightest doubt that one should give preference to a system which assures positive control of the axis of the wheel by a rectilinear gear. Moreover, it should include as few articulations as possible, as they are likely to develop play. Articulations are especially open to criticism when the translatory movement is only partially realized; in such cases gyroscopic reaction still exists, less prominent it is true but still liable to cause shocks.

To make the superiority of positive vertical control

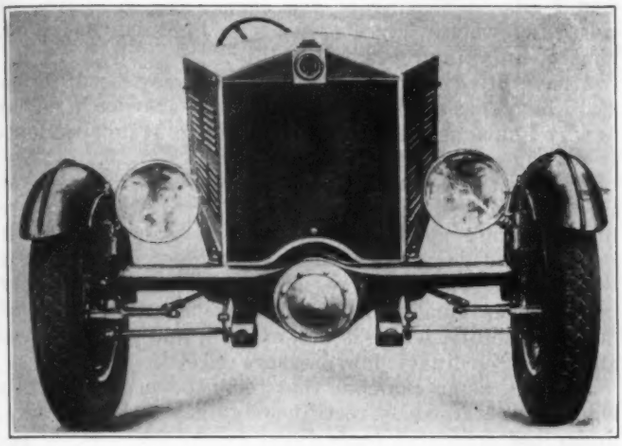

FIG. 4—FRONT-END ASSEMBLY OF DE LAVAUD AUTOMOBILE

The Tubular Axle, Called a Pendulum by the Author, Is Pivotally Attached at the Middle to the Car and Terminates at Either End in Upright Guides Supported on the Steering-Knuckles of the Wheels. Instead of the Customary Frame-Suspension Springs, Rubber Washers in the Guides Support the Weight on the Steering Pivots of the Wheels and Assure Efficient Damping of the Wheel Movements. A Large Friction Disc at the Middle of the Axle Constitutes a Rational Shock-Absorber Which Checks the Oscillations of the Axle. This Construction Results in Two Independently Sprung Wheels Guided in Line, with the Additional Advantage of an Axle That Permits of Three-Point Suspension of the Frame

evident, let us suppose that each front wheel rises or drops around a fixed axis O_1 of the chassis parallel to its own axis O, in Fig. 3. In such cases there must inevitably be important variations in the angle of the cant when the steering pivot $\delta\delta_1$ moves, with the wheel, around the axis O_1. The forward movement is obviously from left to right. The axis O_1 is fixed to the chassis, and the lever length OO_1 is constant, equal to a. The distance h, from O to the plane of the chassis, is a sine α, and the steering rake γ varies like α. Therefore, if the wheel is raised by Δh, the rake is increased practically by $\frac{\Delta h}{a}$ and decreased to the same extent when the wheel drops. As the limits of the angle of rake are somewhat restricted, this is a disadvantage which may be particularly troublesome when that angle becomes negative, the wheel having dropped into a hole. It may then, having no stability of its own, have a tendency to float momentarily around its pivot. The only way to overcome this is to give lever a sufficient length to approach rectilinear guiding. It is also desirable that the steering connections should be sufficiently rigid.

If, for instance, the normal rake is 3 deg. or 0.05 radians, and $a = 500$ mm., this angle will become negative when there is a drop of Δh greater than 25 mm. With such a setting, the wheels should not be cambered, as this would necessarily entail giving a rake to axis O_1. But in this case the movements of the wheels would be transverse.

Again, let me point out that, whatever system of independently sprung front wheels is adopted, gyroscopic reactions must necessarily still exist when the wheels are locked for a turn, exactly as would occur with the commonly adopted type of front assembly. Let me calculate the maximum they are liable to attain. If S be the turning radius, the angular gyratory speed of the car, at a speed V, is $\Omega = \frac{V}{S}$. Assuming the lock to be *constant*, each wheel is subject to a gyroscopic couple having a horizontal axis. If we use the same symbols as before, we find that the amount of this couple is

$$G_1 = \frac{p}{g}\rho^2\omega\Omega = \frac{p}{g}\frac{\rho^2}{RS}V^2 \qquad (2)$$

With the conventional type of front axle we find that the axle takes an inclined position, rising on the side corresponding with the inside of the curve, under the influence of the resulting couple $2G_1$. If the wheels are independently sprung, each wheel has a tendency to lie over toward the outside of the curve.

But if M be the mass of the car and f the coefficient

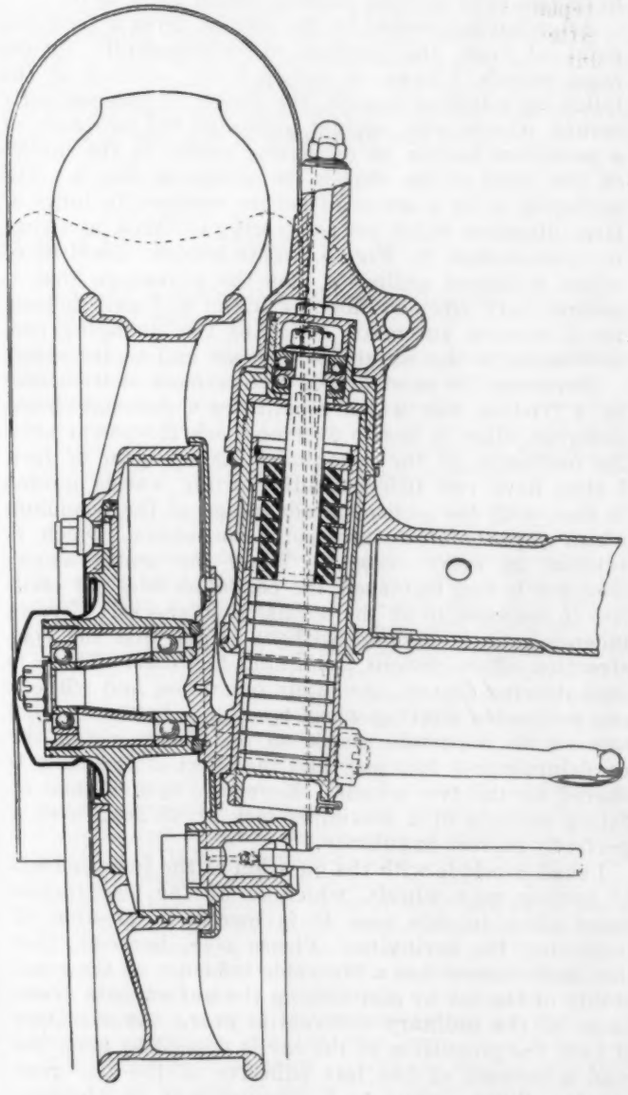

FIG. 5—CROSS-SECTION OF DE LAVAUD FRONT WHEEL AND AXLE END

The Steering Pivot Telescopes in an Upright Guide on the Axle End and Supports the Axle Weight on a Series of Rubber Washers, Which Take the Place of the Usual Leaf Spring. Fully Reversible Dual Steering Control Is Provided

of road friction, the centrifugal force acting on the car is $\frac{MV^2}{S}$, the maximum it can possibly reach being limited by the adherence to fMg. The highest value of $\frac{V^2}{S}$ being fg, it necessarily follows that the maximum G_1 can attain is

$$G_{1M} = fp\frac{\rho^2}{R} \quad (3)$$

Taking the figures we have previously accepted and $f = 0.6$, we get to the result $G_1 = 2.8$ kg-m., which is a very small figure compared with the intensity of gyroscopic reactions. Assuming that the wheels possess a certain angular locking speed ψ, this precession develops another gyroscopic couple which superimposes itself on the couple G_1. To ascertain its value it is necessary only to replace Ω by ψ in the formula which gives us G_1.

After having probed to the bottom, from a technical point of view, the problem of independently sprung front wheels, I have, on my own car, arrived at the following solution; namely, the fitting of independently sprung wheels with upright guides at the two ends of a pendulum having its oscillating center in the middle of the front of the chassis, as shown in Fig. 4. The springing is on a series of rubber washers in tubes of large diameter which act as steering spindles, as shown in cross-section in Fig. 5. This rubber, the life of which is almost unlimited, has the advantage that it assures very efficient damping, clear and well defined, for it ensures automatic action of the springing proportionate to the weight of the car and to its speed.

Moreover, the pendulum is tightly fixed at its center by a friction disc which constitutes a rational shock-absorber, since it has to overcome one movement only, the oscillation of the pendulum. As a matter of fact, I thus have two independently sprung wheels guided in line, with the additional advantage of the pendulum which permits of a three-point suspension, which is rational in every respect. When the center shock-absorber is well tightened, the pendulum does not oscillate in response to all the normal road shocks. Correct independence is assured without joints, and the construction offers obvious machining facilities. There is dual steering control, absolutely reversible, and without any noticeable steering-wheel reaction. In the unusual case of an important shock on one front wheel, the pendulum comes into play and the effect of the blow is shared by the two wheels. Moreover, this method of fitting permits of a maximum lock of 48 deg., with a perfectly correct angularity.

I shall conclude with the question of the independently sprung rear wheels, which is of far less importance since in this case it is merely a question of improving the springing. Please note, however, that this improvement has a favorable influence on the roadability of the car by diminishing the unfortunate drawbacks of the ordinary differential gear. As a matter of fact, the propulsion of the car is dependent upon the road adherence of the less adhesive of the two rear wheels. When, owing to a rebound over an obstacle, one wheel loses its adhesion for a moment, the car is no longer propelled, and the wheel which has bounced increases its rotations. When it once more comes into contact with the road surface, at high speed, there is temporary spinning which diminishes lateral adherence and tends to floating of the rear. The reduction of unsprung weight, since it tends to diminish bouncing, consequently improves roadability.

I have fitted my car with a special gearless differential which does away entirely with this drawback. That is why I have not thought it advisable to fit independently sprung wheels at the rear.

Again, if independently sprung wheels are fitted at the rear as well as in front, that is to say, correctly fitted against gyroscopic action, the rear wheels tilt in the same way and at the same time as the chassis when going round a curve, and if the center of gravity is not exceptionally low, this causes an impression of lack of stability, which is non-existent and yet disagreeable, with ordinary low-pressure tires.

Suppose, as an example, that independence of the two wheels is obtained by rectilinear guiding. On a curve, under the action of centrifugal force, the vertical reaction of the ground increases on the outer wheel and decreases on the inner wheel. Also, by reason of the elasticity of the suspension, one wheel will rise in relation to the chassis while the other will descend. Also, one tire will flatten more than the other. Therefore, each wheel utilizing the superimposed elasticities of the spring and of the tire, the wheels will incline at the same time as the chassis. This defect becomes more marked as the flexibility of the suspension is increased.

It is moreover necessary to point out a fact which is of capital importance, although too often overlooked. If the chassis is carried on either a continuous or a divided rear axle, its inclination on the axles, when making a turn, is determined by the moment of the centrifugal forces of the suspended mass in relation to the plane of the springs. With a very low center of gravity and, possibly, springs not having too great a degree of flexibility, it is quite possible to make this inclination almost imperceptible.

The conditions are very different, however, if the four wheels are independent, with vertical guides, for instance. The relative movements of the wheels in relation to the chassis are then determined entirely by the variations of the vertical reactions received from the road. These variations, on the whole, constitute a couple equalizing the moment relative to the ground of the centrifugal force applied to the mass of the car. The chassis will therefore incline as if, having a normal suspension, it were submitted to the couple represented by the moment in relation to the ground of the total centrifugal force of the car. Other things being equal, indeed, it will incline much more than in the ordinary case, carrying the wheels laterally with it. Even if the center of gravity is lowered, it is impossible to eliminate this defect, which gives to the car a disagreeable impression of instability and accentuates tire wear.

Under these conditions, it ought to be regarded as a mistake, as I have already pointed out, to equip the front and the rear of an automobile with the same arrangement of independently sprung wheels, although the design would be correct considered from the standpoint of gyroscopic effects. That is why I conclude that, if one wishes to have independently sprung rear wheels, it is better to adopt the split-rear-axle principle. The gyroscopic effects still exist but they are of no importance if there is sufficient stiffness of the chassis or of the rear axle. On the other hand, one has a far greater impression of stability in taking corners.

Conclusions

The normal front-wheel assembly, owing to its permanent and its occasional drawbacks, is a construction so imperfect that it is inadmissible in the present state of advancement of the automobile industry.

Its manifestations, which are always troublesome and sometimes excessive, are all due to a common origin, gyroscopic reactions of the wheels which have a natural and unavoidable tendency to set up combined wabbling whenever the axle is inclined. That is why there may appear unbearable vibratory instability or phenomena due to reverberation so intense as to be dangerous.

The conventional axle-assembly is also responsible for violent reactions in the steering-wheel which annoy and fatigue the driver, and precessions which undoubtedly injure the steering-gear. It is also responsible for poor roadability and poor stability, which are such frequent defects.

In a word, the defects of the steering assembly are accountable for the origin of the most serious drawbacks that have made themselves manifest over a number of years since motor-cars have been in use. Its adoption is an error which will surely disappear in the very near future. Besides, the makeshift remedies to which one has recourse and which fail to make their defects tolerable, such as frictional shock-absorbers and irreversible steering, are, from the point of view of sound mechanics, equally incorrect.

The requirements of comfort and ever-increasing speeds already make independent springing of the front wheels an imperative necessity. The best realization consists in rectilinear guiding. It should be associated with an entirely reversible double steering.

Independently sprung rear wheels are not nearly so interesting, and I do not think that solution of the rear-end problem should be arrived at by the same method as for the front wheels. Indeed, the main object here is to improve the springing by reducing the unsprung weight. To avoid that unpleasant floating feeling on curves, it seems to me that it is advantageous to fit the split rear axle.

In closing, let me state that I hope these few technical considerations may help to guide the ever-productive imagination of our engineers, who, I have no doubt, will soon be able to arrive at satisfactory systems of independently sprung front wheels. The motor-car industry will then have made one more step in the path of progress, and one that is imperative and decisive.

The Markets of China

THE Shanghai Automobile Show held in October, 1927, showed that this Paris of the Orient also has its automobile row, where American cars fairly dominate. About 100 cars and motorcycles arrive in the port of Shanghai daily. A census prepared a year ago showed that, of the 179 different makes of car in Shanghai, Buick, Ford and Studebaker top the list in the order mentioned, with these following: Citroen, Chevrolet, Dodge, Overland, Hupmobile, Fiat, Morris Cowley.

Shanghai contains half of all the automobiles in China. It has the distinction of licensing more makes than any other city in the world. More than one-third of all the cars entering Shanghai in 1925 were American. With the good roads movement in full swing and the number of bus lines on the increase, the Shanghai Automobile Show, attended by 2500 persons, revealed healthy prospects. About 70 automobiles and motorcycles were sold during the show.

A study of America's export statistics reveals some views contrary to general opinion. For instance, under the heading "Chemicals and Allied Products," America sold more to China than under the heading "Machinery and Vehicles." Though Germany's chemical trade was hurt by the war, she still fairly leads the world's traffic in the industry. But America has progressed steadily, and today China is an annual customer for American chemicals to the extent of $5,000,000.

Young China is assimilating the Western ideas and making use of Western-style articles in a steadily progressive ratio. The present is only a beginning. The standard of living has advanced considerably in recent years despite wars and amid corruptions. China is no longer a dumping ground for inferior or out-of-date products. It takes consistent efforts and modern goods to buck the Chinese market today.

As the vice-president of the Quaker Oats Co. of Chicago says,

> As much effort is needed to build a business in Shanghai as in Chicago. Not enough manufacturers have gone into China to stay there, with a determination to construct a permanent business, and that is why so many business houses, before the war, fell short of success.

Success in the Chinese field today depends on modifying goods and packages and prices to meet the demand, on finding acceptable ways to use the products, on advertising in a way to meet the Chinese, and on utilizing selling and distributing methods that harmonize with the customs and practices of China's shopkeepers and merchants.

Shanghai Second World-Port in Shipping

Does war in China affect trade? It certainly does. On the other hand, China, it must be noted, is like a sponge which, when squeezed, gives out water, and, when released, drinks it up again. That has been the characteristic of trade in China during the last 10 years of incessant civil war. In 1927, business in Shanghai was cut down 70 per cent due to the troubles there; but it increased 25 per cent in Hongkong, balancing the other. If there is a disturbance in one district, there are probably 50 other districts where it is quiet and where the people still buy.

Statistics published by the Bureau of Domestic and Foreign Commerce, in March, 1927, showed that there was a 12-per cent increase in the sales of American products in China in 1926 as compared with 1925. The total sales to China proper amounted to $110,205,000, to which are to be added $12,819,000, the value of American goods shipped to Hongkong, and $6,466,000 to the Japanese leased territory of Kwangtung (South Manchuria).

Even an old hand in the China trade like Robert Dollar was surprised when he recently consulted the entrance and clearance records of the seaports of the world. The veteran shipper noticed that New York City still leads with 37,000,000 tons of shipping entered and cleared, and rubbed his eyes as he read as follows: Shanghai 28,000,000; Hongkong 22,000,000; London 21,000,000; Liverpool 19,000,000.

Imagine the great port of London superceded by two seaports of China! It gives the best picture of what has happened, and will happen, in that magic land to which Marco Polo journeyed centuries ago.—Arthur A. Young in *Trade Winds*, Union Trust Co., Cleveland.

The Measurement of Riding-Qualities

By Roy W. Brown[1]

Annual Meeting Paper — *Illustrated with* Photographs, Drawings and Charts

AN accelerometer of the contact type, that employs a new means of suspending the weight, has been developed which is said to eliminate all the contact error and troubles previously experienced with this type of instrument. A counter of sufficient speed to count accurately the accelerations which occur in road service has been developed also, and a complete instrument comprising six elements has been constructed and is described.

Due to the relatively small size of the accelerometer and to its remote connection with the counter, the instrument can be mounted on a vehicle axle or on any other portion of the vehicle desired. This enables measurement to be made of the accelerations transmitted through the tires alone, through the tires and springs, or, if desired, through the tires, springs, body, and seat cushions. With a single instrument or by using separate accelerometers located in different positions, the riding-qualities of any individual portion of the vehicle can be segregated readily.

The combination in one instrument of remote indicating means, relative simplicity, ability to change the range by manipulation of a rheostat, and ruggedness of the accelerometer proper has heretofore been unobtainable in the various devices designed for the measurement of vibrations. This new instrument therefore should assist those interested in researches having to do with vibrations and accelerations.

SEVERAL years of research over various highways and byways of the Country in an effort to measure the riding-qualities of motor-vehicles of different types has resulted in the development of a reasonably simple, practical and rugged instrument of the counter-contact accelerometer-type. Extreme ruggedness of the actuating element is paramount if an instrument is to retain any semblance of accuracy after passing over bad or indifferent roads when attached to a truck axle. Attachment to the axle is required if the riding-qualities of tires are to be segregated from those of the vehicle as a whole.

Construction and use of elementary forms of the contact-type accelerometer, as described in my paper on Instrumentation and Results of Riding-Qualities Tests[2], indicated that the most practical instrument would be one which would count all accelerations occurring above a predetermined value. The present instrument is arranged with six accelerometer elements, each element being connected with a separate counter. Hence, at the end of a run, the number of accelerations occurring between six predetermined values can be read directly from the counters. Experience indicates the use of a recorder as impractical if the results of a run of several miles are to be analyzed, as the total number of accelerations occurring per mile runs into the thousands. Therefore, the analysis of a long run is extremely laborious.

The use of integrating devices apparently offered a desirable alternative to the recording device. However, in the early type of contact accelerometers, it was found that the making or breaking of the contacts was very indefinite and that a large amount of chatter existed. Obviously, if an electrolytic or other electric integrator were to be used, the time the contacts are open or closed must be proportionate to the time the acceleration exceeds the predetermined value. A calibration machine, especially designed to give simple harmonic motion, also described in my former paper[3], showed conclusively that accurate records cannot be obtained, when using an integrator as the indicating means, with accelerometers on which the contacts chatter.

The Solenoid Accelerometer

In former contact-type accelerometers the weight was supported by a spring or by air pressure. Replacement of the spring or air pressure with a solenoid resulted in the elimination of contact chatter, this desirable condition being a result of the inverse load-position characteristics of an iron core in a solenoid, as shown in Fig. 1. The force tending to hold the contacts together decreases very rapidly with slight downward movement. Hence, when an acceleration is reached that

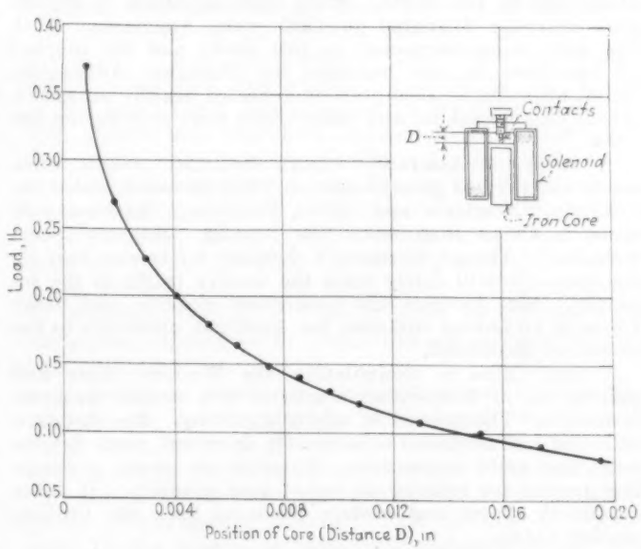

Fig. 1—The Solenoid Accelerometer

The Force Tending To Hold the Contacts Together Decreases Very Rapidly with Slight Downward Movement. Hence, When an Acceleration Is Reached Sufficient To Start Motion of the Core Downward, the Movement Is Propagated by the Rapidly Decreasing Restraining Force

[1] M.S.A.E.—Mechanical engineer in charge of engineering laboratories, Firestone Tire & Rubber Co., Akron, Ohio.

[2] See The Journal, June, 1926, p. 594.

[3] See The Journal, June, 1926, p. 596.

is sufficient to start motion of the core downward, the movement is propagated by the rapidly decreasing restraining force.

Previous efforts to eliminate this outstanding defect, contact chatter, in contact accelerometers resulted in the introduction of other undesirable errors which are discussed in articles on Contact-Accelerator Gap-Clearance[4], and Gap-Error[5]. This also resulted in a very definite time-interval of contact opening as, when the downward force on the plunger due to acceleration exceeded the upward force due to the solenoid pull, the plunger moved downward and remained down until the acceleration decreased appreciably below the contact-opening value on the succeeding quarter-cycle of the acceleration-time curve. The time interval of contact opening was found sufficient to permit the operation of a counter.

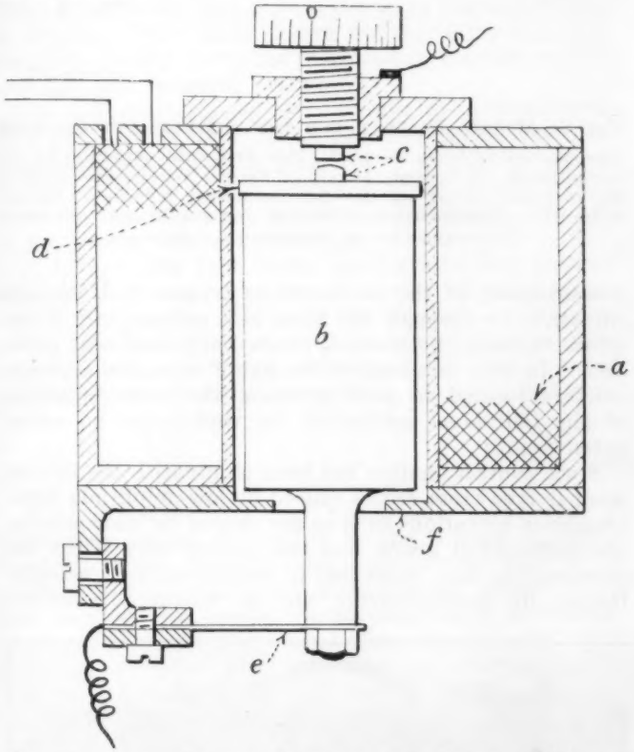

FIG. 2—DIAGRAMMATIC VIEW OF THE PRESENT FORM OF SOLENOID ACCELEROMETER

Magnetism from the Iron-Clad Solenoid *a* Tends To Lift the Weight *b* and Force the Contacts *c* Together. In Operation, This Force Is Opposed by Vertical Acceleration and the Contacts Open When the Downward Force Due to Vertical Acceleration Becomes the Greater. The Weight *b* Is Guided in the Solenoid at *d* and at Its Lower End by the Cantilever Spring *e*. The Latter Also Serves as an Electrical Connection to the Lower Contact. The Downward Travel of the Weight Is Limited by the Stop *f*. The Upper Contact at *c* Is Arranged on a Micrometer Screw. By Varying the Setting of the Micrometer Screw and the Cantilever Spring *e*, the Calibration of the Accelerometer Element Can Be Changed

Fig. 2 is a diagrammatic view of the present form of the instrument, in which the magnetism from the iron-clad solenoid *a* tends to lift the weight *b* and force the contacts *c* together. In operation, this force is opposed by vertical acceleration and the contacts open when the

[4] See THE JOURNAL, November, 1926, p. 433.
[5] See THE JOURNAL, August, 1927, p. 121.

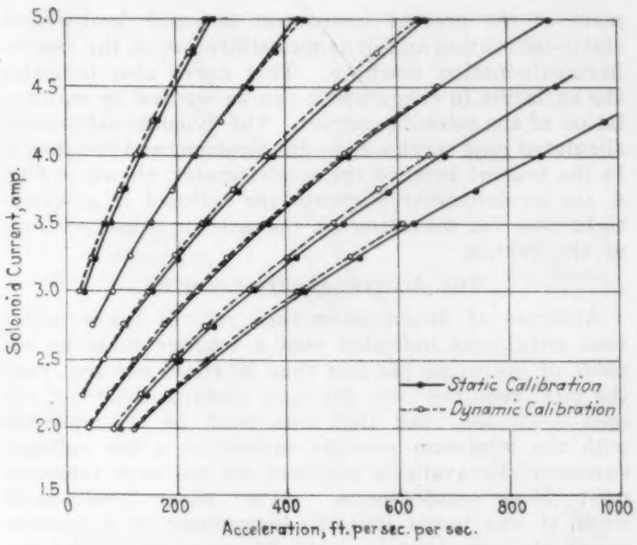

FIG. 3—STATIC AND DYNAMIC CALIBRATION CURVES

Close Agreement Between the Static and Dynamic Curves Is Apparent. This Curve Also Indicates the Variation in Range Which Can Be Secured by Manipulation of the Solenoid Current

downward force due to vertical acceleration becomes the greater. The weight *b* is guided in the solenoid at *d* and at its lower end by the cantilever spring *e*. The latter also serves as an electrical connection to the lower contact. The downward travel of the weight is limited by the stop *f*. The upper contact at *c* is arranged on a micrometer screw. By varying the setting of the screw and the cantilever spring *e*, the calibration of the accelerometer element can be changed. A feature of convenience in use is the variation of range which can be secured by changing the current in the accelerometer solenoids.

One of the outstanding features of all contact accelerometers is the feasibility of absolute calibration by using dead weights. Fig. 3 shows the close agree-

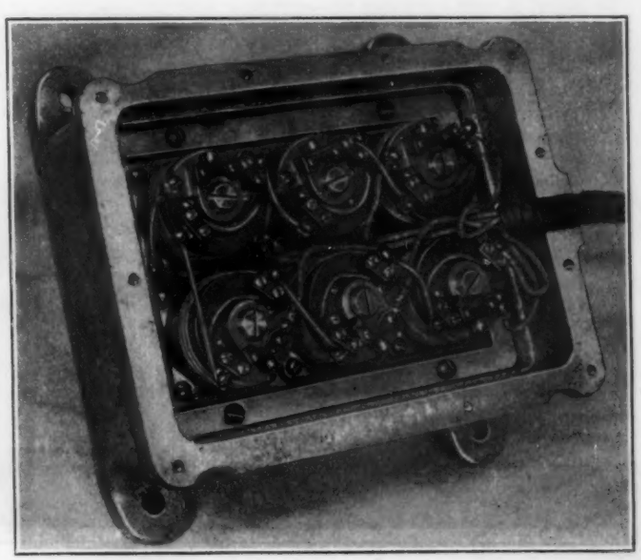

FIG. 4—PRESENT FORM OF THE ACCELEROMETER

Six Accelerometer Elements Are Enclosed in a Water-Tight Case for Mounting on the Axle or Other Portions of the Vehicle

ment of the present instrument between dead-weight static-calibration and dynamic calibration on the simple-harmonic-motion machine. This curve also indicates the variation in range which can be secured by manipulation of the solenoid current. The dynamic calibration simulated road service as to displacement and frequency. In the present form of the accelerometer, shown in Fig. 4, six accelerometer elements are enclosed in a water-tight case for mounting on the axle or other portions of the vehicle.

The Accelerometer Counter

Analyses of displacement-time records taken under road conditions indicated that a counter must be capable of operating not less than 40 times per sec., that the total required time for open contacts must not exceed 0.003 sec., and that this must be accomplished with the minimum possible current at a low voltage. Commercially available counters did not even remotely meet these requirements. After some development work, it was found that the escapement of a conventional clock-mechanism could be operated at the required rate by a differential magnet on a current consumption of 0.05 amp. at 6 volts. A six-element counter of this type was constructed as shown in Fig. 5. The counter mechanisms, the Wheatstone bridges and meters showing the current in the accelerometer solenoids and the voltage on the counters are all incorporated in one self-contained unit. The wiring diagram for the counter, as connected to the accelerometer, is shown in Fig. 6. Like a radio-circuit diagram, Fig. 6 only appears to be complicated. It consists merely of several Wheatstone bridges, the counters acting as the galvanometers; necessary meters, batteries, a polarity-reversal switch, and test plugs; and their connections to the accelerometer solenoids.

Application and Results

Due to the relatively small size of the accelerometer and to its remote connection with the counter, the accelerometer can be mounted on a vehicle axle or on any other portion of the vehicle desired. This enables

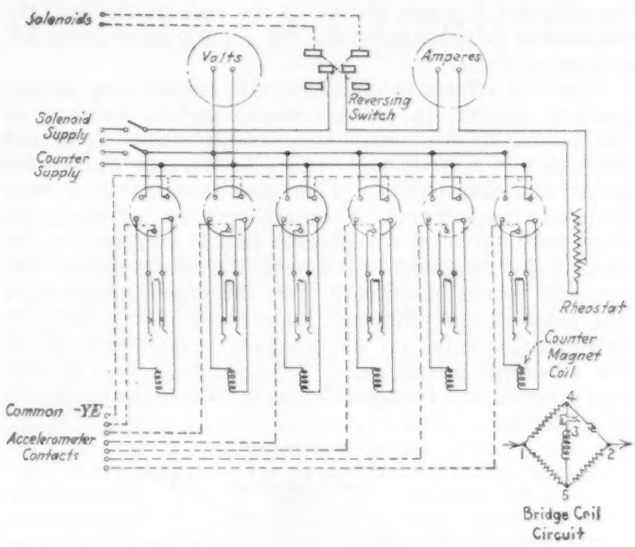

FIG. 6—WIRING DIAGRAM FOR THE SIX-ELEMENT COUNTER

Like a Radio-Circuit Diagram, This One Only Appears To Be Complicated. It Consists Merely of Several Wheatstone Bridges, the Counters Acting as the Galvanometers; Necessary Meters, Batteries, a Polarity-Reversal Switch, and Test Plugs; and Their Connections to the Accelerometer Solenoids

measurement of the accelerations transmitted through the tires, or through the tires and springs, or, if desired, through the tires, springs, body, and seat cushions. In this manner, or by using separate accceleerometers located in each position, the riding-qualities of any individual portion of the vehicle can be segregated readily.

Since contact chatter has been eliminated, the instrument is free from errors caused by low-amplitude high-frequency vibrations such as are caused by transmission and differential gears, and will record only when the acceleration has exceeded a predetermined amount. Hence, the accelerometer can be mounted wherever

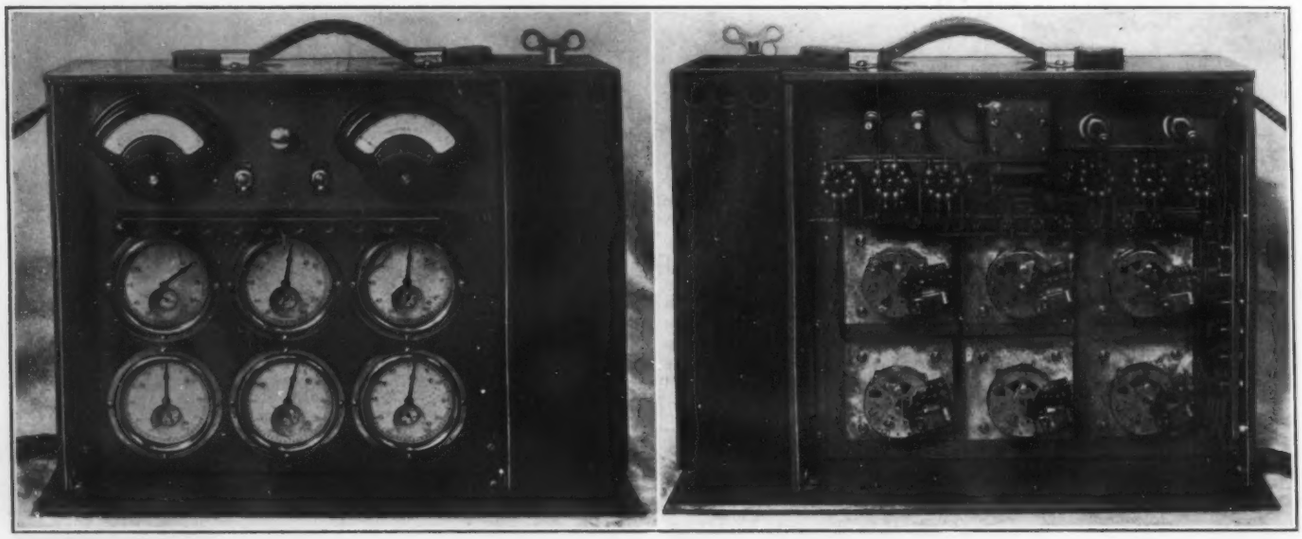

FIG. 5—SIX-ELEMENT COUNTER

A Special Counter Was Developed Which Will Operate 40 Times per Sec. on a Very Low Electrical Input. The Counter Mechanisms, the Wheatstone Bridges and Meters Showing the Current in the Accelerometer Solenoids and the Voltage on the Counters Are All Incorporated in One Self-Contained Unit

desired without regard to high-frequency low-amplitude vibrations.

Study of Tires

In studying the riding-qualities of tires, it was found desirable to record the results over a relatively long run, perhaps as much as 50 miles. This procedure minimized the effect of the large number of variables which are bound to occur in driving on public highways and, it is believed, gives a good average performance for the particular equipment under test. Obviously, the tests could be extended to include various types and conditions of road, driving speed, tire-inflation pressure, vehicle load, spring-suspension, and numerous other conditions that result in actual service.

Fig. 7 shows some typical results which were obtained in preliminary tests of the solenoid accelerometer. The ability of the instrument to differentiate between different inflation-pressures in pneumatic tires is evident. The curve shown substantiates generally accepted opinion as to the relationship between riding-qualities and inflation pressure.

The difference caused by a change in inflation pressure of 5 lb. is very noticeable and shows that the instrument is sufficiently sensitive to indicate the effects of major factors of tire design, such as tread contour, provided the data are taken over a sufficiently long run to get a true average condition.

It is probable that many applications will suggest themselves to engineers who desire to measure vibrations. The remote indicating means, the relative simplicity, the ability to change the range by manipulation of a rheostat, and the ruggedness of the accelerometer proper, combined in one instrument, provide a combination which has heretofore been unobtainable in various devices designed for the measurement of vibrations and should appreciably assist those interested in researches having to do with vibrations and accelerations.

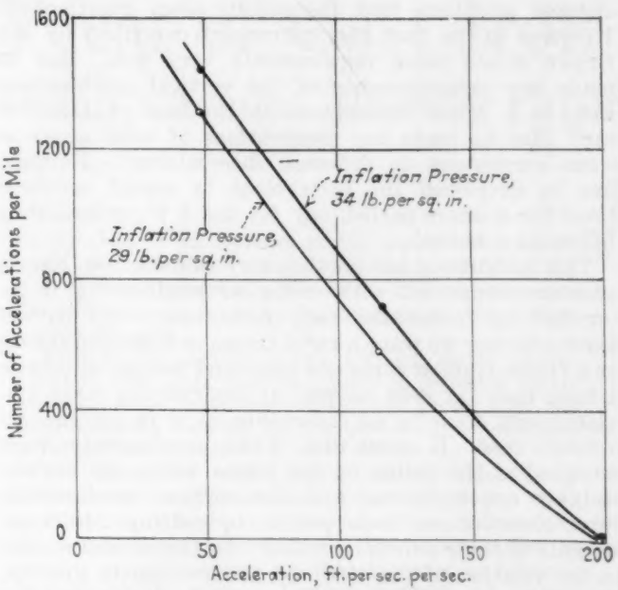

Fig. 7—Typical Results Obtained from the Solenoid Accelerometer

The Ability of the Instrument To Differentiate between Different Inflation-Pressures in Pneumatic Tires Is Evident. The Curve Shown Substantiates Generally Accepted Opinion as to the Relationship between Riding-Qualities and Inflation Pressure

THE DISCUSSION

B. J. Lemon[6]:—Several years ago a project of measuring impact was begun by the Bureau of Public Roads in which the different types of tire were to be employed on different types of commercial vehicle. When that research was begun, the development of accelerometers was in a primitive stage. The company with which I am connected developed a sylphon accelerometer which was sent to the Bureau of Standards, but when it was put on light trucks having worn solid-tires the accelerations were too great for the instrument. The Bureau of Standards developed a contact accelerometer which has been used in modified forms for several years. Mr. Brown is thoroughly familiar with this piece of research work. How much more accurate is the type of accelerometer described by Mr. Brown than is the type used by the Bureau of Public Roads?

R. W. Brown:—To function in the time interval which is available when a truck tire, especially a worn solid-tire, hits an obstruction on the road and goes over it, an instrument must perform quickly. If the instrument has natural periods or other characteristics which make it a relatively slow-moving piece of apparatus, it does not record or indicate the true conditions. This phase of the matter has been analyzed in theory, mathematically, by numerous authorities and is a matter of record available to all. It it sufficient to say that the present instrument, owing to its unique construction and fundamental characteristics, is entirely free from this effect. Any motion caused by vertical acceleration which is of sufficient magnitude to open the contacts, registers, irrespective of its time interval. Unquestionably, the instrument used by the Bureau of Public Roads has served a specific purpose. It was a forerunner of other types and has been very largely used. Most initial products are out-dated rather shortly, and the best way in which to handle research engineering projects is to change over to newer and better instruments as soon as they are available.

Speaking of accelerometers in terms of percentage error, that is a function largely of the conditions and may vary anywhere from 5 to 200 per cent in the case of the Bureau of Public Roads instrument. The limitations in accuracy of the present instrument do not lie in the instrument itself, but in the number of cells or elements which one can concentrate into a practical instrument. Suppose one instrument has an element set for an acceleration of 50 ft. per sec. per sec. and that the next element is set for an acceleration of 55 ft. per sec. per sec. If the first element registers and the second does not register, the correct value lies between the two elements; hence the result is accurate to within 5 ft. per sec. per sec.

F. C. Mock[7]:—One of the first needs in any serious investigation of the subject of riding-quality is an accelerometer that is robust, dependable, easily handled, and of such nature that the calibration can be re-

[6] M.S.A.E.—Field engineer, tire development department, United States Rubber Co., Detroit.

[7] M.S.A.E.—Resarch engineer, Stromberg Motor Devices Co., Chicago.

checked any time that the results seem questionable. It seems to me that the instrument described by Mr. Brown meets these requirements very well. Has he made any measurements of the vertical accelerations such as a driver experiences in the seat of a motor-car? Has he made any observations of what accelerations correspond to different discomforts? Further, has he developed the instrument to record accelerations for a short period, say for the 8 ft. immediately following a bump?

This instrument has another very valuable use. Nearly everyone connected with motor-car engineering is interested in frame and body deflections. We do not know whether we want a rigid frame or a flexible frame, or a frame rigid at some one point and flexible at others. I have thus far seen no way of determining what displacements occur in an automobile as it is driven over a rough road. It seems that, if this accelerometer were mounted at the points on the frame where the various weights are supported and the vertical accelerations were observed at these points, by setting additional weights at these points increased over the normal weight in the relation of the observed acceleration to gravity, it would be possible to create statically the deflections and displacements that occur momentarily on the road. At least we would have more definite information than we have thus far been able to obtain.

MR. BROWN:—We have shifted the accelerometer to various locations on the car. It records on the seat portion very nicely. That is the least difficult position of any we find on the motor-car. The most difficult location we found was directly in the center of the rear axle, with improperly adjusted bevel-drive gears.

We have also developed a recorder for the instrument; in fact, the recorder was developed before the counter. It works very well and, in certain instances, is of distinct value; but it is extremely laborious to analyze the record because, to secure even comparative results, the car must be run over a number of obstructions. Sufficient mileage must be obtained so that the law of averages has a chance to function. Even in repeated runs over short artificial roads with artificial obstructions it is difficult, if not impossible, to run over an artificial obstruction in the same manner time after time. For that reason we abandoned that method of work and developed apparatus which would give us with reasonable convenience a means of averaging what happened in regular service.

GEORGE L. MCCAIN[8]:—In a progressive test, when integrating at the completion of the run, how do you know where the oscillations belong?

MR. BROWN:—The counter does not show where the accelerations occur. To get that, one must use a recorder.

LOCATING VIBRATION ORIGIN

BORIS P. SERGAYEFF[9]:—It seems to me that Mr. Brown's instrument will give a rough check of what happens. For instance, when the car is operated his device will give a record better than that of the other device, but where the oscillations originated will be difficult to locate. With a soft tire and hard springs, the record will be the same as with a hard tire and soft springs; hence this instrument will not show where all the shocks originate.

Methods used by Prof. W. E. Lay, using photographic records, can be better applied for such a purpose, I think. This kind of record can give anything desired. If the lights are fixed on the car body and on the chassis, one can see by the picture what deflection occurred, how strong the vibration was, how the body was deflected, and when the wheels left the road entirely. It seems to me that Mr. Brown's device is very good for a rough check; but, for analytical purposes, I prefer Professor Lay's method.

MR. BROWN:—By using three actuating elements with separate counters, putting one on the axle, one on the chassis or above the spring or at the spring-block mounting, and one on the seat cushion, and then subtracting the values shown by the different counters, the relative effects of tire, spring and seat cushion on damping out acceleration can be obtained.

PROF. W. E. LAY[10]:—The tests to which Mr. Sergayeff refers were made by putting lights on the front and the rear axles, the front and rear of the body, and on the man sitting in the seat. That type of test perhaps does give us something that the other does not, but it is not practicable over any long period. So, both methods have their uses.

WALTER C. KEYS[11]:—I had some experience several years ago with the electric-light method of testing. One rather serious point at present is that it is practically impossible to make an electric-light record of a passenger or a driver in a closed car, because part of the time that the car passes in front of the camera the light on the passenger is hidden by the side pillars of the body. That makes it rather an impracticable method to use, except in open cars with the top down.

Mr. Brown's apparatus, which I think has much merit, seems to show that the summation of these accelerations perhaps is an integrated factor, corresponding to fatigue of the passenger.

OTHER TESTS DESIRABLE

I should like to have someone make a series of careful studies on the effects of such things as the commercial variations in flexibility of springs. One can specify a spring having a certain deflection, but not very many of that specific rate will be found in the season's production. It would be illuminating and helpful to a designer of spring suspensions to know what effect these commercial variations in flexibility would produce upon passengers. That would apply also to cushion springs and to shock-absorbers. We are coming to the day of hydraulic shock-absorbers, and there must be a considerable difference in the action when the liquid is cold, compared with the condition when the liquid is warm. Studies of these things should be made, and I hope that someone will make them in the near future.

I should like also to have someone make tests over a bump, so that the front wheels of the car could pass over it and then, before the rear wheels pass over it, have the bump or obstacle suddenly drop to the level of the pavement. That would enable us to study more intelligently the effect of the front-end and the rear-end suspensions independently of each other.

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[9] M.S.A.E.—Engineer, General Motors Corporation Research Laboratories, Detroit.

[10] M.S.A.E.—Associate professor, mechanical engineering, University of Michigan, Ann Arbor, Mich.

[11] M.S.A.E.—Chief engineer, automotive development department, United States Rubber Co., Detroit.

Machinability and Wear of Cast Iron

Discussion of Thomas H. Wickenden's Annual Meeting Paper[1]

THE hardness or chemical composition of an iron is, by itself, no indication of the wearing property and machinability of the iron. Irons containing a large amount of free ferrite have been found to wear rapidly, whereas others having considerable pearlite or sorbite in their structure show good wearing properties. The presence in cylinder-blocks of excess-carbide spots or of phosphides of high phosphorus-content is deleterious, because such spots wear in relief and the material ultimately breaks out, acting as an abrasive that scores the surfaces.

Causes of wear in cylinder-blocks are discussed, and nickel, or nickel and chromium, intelligently added to the iron is suggested as a means of obtaining the correct microstructure for a combination of good wearing properties and machinability. Since greater hardness is the result of a harder matrix rather than of an increase in the number of carbide spots, it has been found to be a good index of the improved resistance to wear, and to overcome the difficulty due to the hammering of the valves into their seats.

Analyses of cylinder-blocks, pistons, clutch plates, brake drums, cams, and forming-dies, in which nickel and chromium have been used, are given, and the improvements secured in the performance of these parts are described.

The discussion treats largely of the relationship between hardness, lubrication, finish and wear. Wear is stated to be much more dependent upon lubrication than upon quality of the iron. The use of nickel in iron is stated to improve the tightness and homogeneity of the metal. Various methods of testing iron for machinability are outlined.

ORLAN W. BOSTON[2]:—It is not clear to me what the relationship is between the machinability of cast iron and its wearing qualities, as lubrication would effect the wear.

Some companies are now boring their bronze bushings with a diamond tool, removing the burnished surface, instead of broaching them. It has been accepted in the past that a burnished surface with high luster is the best wearing surface. The theory of the better wearing qualities of the new-style bored bearing is that its roughness provides small pockets for the lubricant.

There are a number of ways of designating machinability; almost every company has its own means. Sometimes the Brinell test is used on castings and forgings, but that means very little as an indication of tool life. I assume that the author has referred to machinability in terms of tool life, not the quality of the finished surface.

THOMAS H. WICKENDEN:—There is no question that the three factors, machinability, wear, and finish, are closely related. In the paper, a casting with good machinability means one on which a cutting tool will last for a considerable time without regrinding, and a casting with poor machinability is one on which the tool will dull rather rapidly.

Finish and wear are closely related. There is no question that the present cylinder-block, with its highly polished surface, has a better start than the reamed blocks of 10 years ago. It will wear much longer than one that had a rough finish originally.

We are familiar with the glazing of cast iron, but it is something we know little about. Probably it would be well to make a further study of this question. Some irons seem to glaze more readily than others.

LUBRICATION IS THE PRIME ESSENTIAL

L. A. DANSE[3]:—We think this whole question is one of lubrication more than anything else. Without good lubrication we might need to pay more attention to the structure and hardness of the iron. We do not want to have the iron too soft, principally because of the psychological characteristics of the production-engineering staff. I do not believe that the softness of the iron makes the cylinder and the piston wear faster if they are well oiled. Lubrication is much more important than the characteristics of the iron.

We do not use plain iron because it is almost impossible to cast a plain-iron cylinder-block in our present multi-bore design so that it can be manufactured. We do not know how to control our foundry practice in any way that will allow satisfactory production speed with plain irons. One of the best projects that the Society can undertake in connection with the machinability of cast iron is a standard machinability test. Some of the General Motors men evolved a method of their own, using an electric-motor drive and standard appliances for grinding the drills. This is the best way of which we know.

E. P. BLANCHARD[4]:—We are using nickel in some of our foundry mixtures for machine-tool parts. We make test bars for every ladle-full of iron that is poured in our foundry and test them for tensile strength, Brinell hardness and machinability. We do not use a shaper; we use a drill, directly motor-driven at a standard speed, and a standard test-bar, timing the progress of the drill through the bar. The drill is of standard size, with a standard grind immediately before drilling. We thought we were quite original in this until, in some work with Professor Boston two or three years ago, I discovered that two German engineers did it long before. With nickel mixtures, in some cases, we can get higher tensile strength and a closer structure in the

[1] This paper was published in THE JOURNAL for February, 1928, p. 206. The abstract is reprinted herewith for the convenience of readers of the discussion. The author, who is a Member of the Society, is in the development and research department of the International Nickel Co., New York City.

[2] Professor of shop practice and director of shops, University of Michigan, Ann Arbor, Mich.

[3] Metallurgist, Cadillac Motor Car Co., Detroit.

[4] M.S.A.E.—Advertising and assistant sales manager, Bullard Machine Tool Co., Bridgeport, Conn.

iron and still maintain our factor of machinability, as shown by the method of testing which I have described. As to the wearing qualities, the one part that I have in mind is our table spindle, which has a wide conical bearing; and we shall have to wait until wear begins to show to tell about that.

Can Lubrication Be Maintained?

QUESTION:—Is lubrication between piston-rings and the cylinder-wall ever good enough so that anyone can afford to neglect the wearing properties of iron with partial lubrication?

MR. DANSE:—We aim to maintain better than a partial film; we expect nearly a full film, or a film a large percentage of the time. When we have this there is very little trouble with wear unless the lubricant becomes loaded with abrasive material, such as road dust. That might cause considerable difficulty. We are quite sure that close-grained iron, which can be easily machined, will wear well if proper lubrication is maintained.

One function of the nickel alloying element in cast iron is to give a tight material; another is to make it homogeneous and uniform. Aside from making a tight and close-grained casting, I do not know whether nickel affects the wearing properties. With reasonable lubrication, such as we have in most automotive construction, there is little trouble. A series of tests at the General Motors Research Laboratory revealed some very interesting things about the wearing properties of iron. Irons of 15 or 18 different analyses were made, with hardness ranging from 100 to nearly 300 Brinell. The difference in wear was negligible, so long as a film of lubricant was maintained. The film might be oil or tar or rubber or even soapy water; as long as the film is there the iron will resist wear.

Lessons from Veteran Cars

RALPH H. SHERRY[5]:—I should like to confirm Mr. Danse's statement. Combined carbon is desirable in a cylinder-barrel but is not always obtained without having too much in flanges and other portions that cool more rapidly than the barrel. Low combined-carbon does not necessarily mean rapid wear, if some examinations of cylinder-barrels from service are a guide. In the cylinder-barrels of three old cars that had run 50,000 to 70,000 miles, the combined carbon was found to be from 0.08 to 0.12 per cent. The wear was slight, only about 0.003 in. Lubrication had been good. Another cylinder from service, found to have 0.40 per cent of combined carbon in the barrel, showed heavy wear, evidently due to poor lubrication. The flanges of this casting were too hard.

Trials with chromium-nickel and nickel iron favored the nickel, but there is no indication that the addition of these elements increases wear or that low combined-carbon means rapid wear. Wear depends upon lubrication, primarily.

MR. DANSE:—Cylinder trouble often is due to corrosion rather than to wear. T. A. Boyd, of the General Motors Research Laboratory, has presented a splendid paper[6] in which that subject was treated.

[5] M.S.A.E.—Consulting metallurgical industrial engineer, Evanston, Ill.

[6] See THE JOURNAL, June, 1926, p. 641.

Tests for Machinability

PROFESSOR BOSTON:—Several things occur to me that are of interest in regard to methods of testing machinability. At the University of Michigan we have equipment for measuring the machinability of metals by several different methods.

First, we have a motor-driven 36-in. shaper equipped with a recording device to measure the power consumption of a standard tool cutting any metal. I have little faith in this method, as the wattmeter readings indicate the total power-input for the machine, while other methods measure the output, or the effect at the tool point.

Second, we have a 36-in. x 12-ft. planer on which is mounted a dynamometer to measure the force in the direction of the cut of a tool standardized for this particular purpose. This will measure a force up to 6000 lb., within an error of 1 per cent or certainly not more than 2 per cent. I believe this to be the best method of measuring machinability in relation to the force required for cutting.

Third, we have a drill-press on which is mounted a dynamometer that will register independently the torque and thrust imposed upon a drill, standardized for the test. As the thrust absorbs not more than 1 per cent of the total power consumption, torque is the prevailing factor, and tests I have conducted show that the torque for a given metal corresponds very closely to the force on the planer tool. If one is high, the other is high, and the tool curves will be more or less parallel.

A fourth method is testing with a drill, having a definite load on the spindle and measuring the penetration for say 100 revolutions of the drill. This is the method to which Mr. Blanchard referred.

In all these tests it is a question as to just what is measured. They measure the ease of cutting, but are we particularly interested in that? So far as I am aware, the force on the tool has no definite relation to tool life. Perhaps, it is more closely related to the Brinell hardness. We are measuring the machinability of a number of cast irons and non-ferrous metals by all of these methods and trying to determine the one that indicates most closely the characteristic in which we are most interested, which is the endurance of a tool such as a boring or turning tool. Unfortunately, it is not practical for us at the University to have sufficient test bars to wear out the tools. That can be done only in commercial operation.

My own experience has shown absolutely no consistent relation between Brinell, Rockwell and scleroscope numbers, or between those numbers and the force required to cut the metals, as a group. Brinell does indicate the force on a standardized tool, however, for some steels in one group, other steels in a second group, and cast irons in a third group.

Hardness and Machinability Not Related

MR. WICKENDEN:—In the first part of the paper I tried to emphasize that there is no general relation between the hardness of an iron and its machinability. This was illustrated by the fact that several irons of the same Brinell hardness showed widely different machining characteristics, which was explained by the difference in microstructure. This difference was shown to be due to free carbides or phosphides in the iron, which increased the difficulty of machining entirely out

of proportion to the increase in hardness. Further, if the hardness of the iron was increased without the presence of free carbides, then the difficulty in machining was about in proportion to the hardness of the iron. Cases can be cited where an iron of 180 Brinell hardness, containing free carbides, gave more difficulty in machining than an iron of 240 Brinell hardness which was free from these carbide particles.

There is no argument over the question that proper lubrication is a prime factor in preventing wear between two rubbing surfaces, but when the lubrication is sparse or the unit pressures between the surfaces are extremely high, tending to squeeze out the lubricant, then the wear-resistant properties of the metals themselves play the important part. The latter condition exists between gear teeth, in some cam actions, often in forming dies, and in unlubricated brake-drums. In these cases, the nature of the cast iron is of vital importance, and tests have shown that an iron of high hardness, free from free carbides, results in the best combination of wear combined with ability to machine the piece. As stated in the paper, iron of this type, with Brinell hardness of 260 or more, was found to be machinable without difficulty because of its freedom from hard spots; and it increased the life of cams, dies and gears to 5 or 10 times the life previously obtained.

W. S. HOWARD[7]:—Which methods of applying the nickel to the mixture give the most uniform and homogeneous metal; adding the nickel in the ladle at the spout, or having it in the pig and putting it into the cupola?

MR. WICKENDEN:—Properly handled, I think there is no choice; most of the nickel now is being added in the spout, and, if this is properly done, the results are very uniform. There are certain precautions to observe in making the additions, namely: to prevent the nickel from touching the sides of the spout, in which case it would tend to stick and not mix uniformly; and to get it under the surface of the metal without getting it on the bottom of the ladle. We have developed several methods of doing this and have made tests of the nickel content in every casting made from a large ladle, finding that the nickel checked as closely as you would expect any series of chemical analyses to check.

MR. DANSE:—Our experience is that the size of the shot has something to do with that. If the shot is not too large the diffusion is good.

[7] M.S.A.E.—Chief Inspector, White Motor Co., Cleveland.

Facilities for European Motor-Touring

MORE than $30,000,000 will be spent in European countries this year by American motor-tourists, who will take 4000 cars abroad, according to *Motoring Abroad*, annual publication of the foreign division of the American Automobile Association. Foreign governments are cooperating with the A.A.A. in its efforts to simplify customs regulations and to remove all possible annoyance in connection with foreign touring. Steamship lines have arranged to transport automobiles uncrated and at a flat rate according to weight.

The A.A.A. is a member of the Alliance Internationale de Tourisme, which is composed of the leading touring clubs of Europe and the United States and has a combined membership exceeding 2,500,000. The A.A.A. is empowered to issue the necessary customs documents which will permit a car to circulate through the various foreign countries without the payment of duty.

American license-plates and driving-licenses are not honored in most European countries; therefore, there is required, in addition to American passports, a *triptyque* or *carnet de passages en douanes*, and an international traveling pass. The *triptyque* is a customs pass for temporary importation of a car into only one country. The *carnet de passages en douanes* (customs carnet) is an international pass for importation of the motor-vehicle into 12 of the most important touring countries of Europe, including Great Britain, the Irish Free State, France, Italy, Belgium, Switzerland, Holland, Germany, Austria, Norway, Denmark and Sweden. American licenses are accepted in Italy.

The amount of duty which the A.A.A. assumes to the various foreign governments by their issuing the *triptyques* or customs carnet must be covered by members through arrangements with the foreign division.

The international travel pass, which is secured in advance for members by the foreign division, eliminates the necessity of re-registering in each of the countries visited and is used in the same manner as American driving-licenses.

Port representatives of the A.A.A. will be found at Antwerp, Boulogne, Bremerhaven, Cherbourg, Genoa, Glasgow, Gothenburg, Hamburg, Havre, Liverpool, London, Naples, Plymouth, Queenstown, Rotterdam and Southampton.

Robots

MAJOR RAYMOND PHILLIPS, of London, is reported to have invented an apparatus, somewhat similar to the Televox, which will stop all the machinery in a factory whenever anyone shouts "Help!" A Connecticut engineer claims to have constructed a device which opens his garage door, starts the engine and drives the car to the front steps on spoken order to a microphone inside the house. However, these are not the real uses for such inventions. It is probably less trouble to go get the car than to keep the temperamental electric gadgets in working order. Mechanical Robots to do our daily work are entirely possible; they are even easy. But nobody would want them. Most men would rather climb into bed unassisted than have a cog-wheel valet tuck them in.

It is otherwise with tasks that men fear. A mechanical observer will take the place of a human being in the crater of a volcano, and send through unwavering reports till it is destroyed. Three-fourths of the earth's surface, covered by the deep sea, no man has ever seen. Electric eyes, ears, and arms sent down 6 miles beneath the waves might report strange things of fish with luminous lanterns, and life under a water pressure of 5 tons to the square inch. Let the more practical-minded think of a machine that could find the sunken gold in a lost treasure ship, load it in a bucket, and send it up a rope.

What these inventions are most apt to do is to take over the tasks too dangerous or too disagreeable for men. They are merely new tools to better the senses, lengthen the arms, and ease the labors of mankind.—E. E. Free in *Review of Reviews*.

Scientific Valve Reconditioning

By JACK FROST[1]

NEW ENGLAND SECTION PAPER — *Illustrated with* DRAWINGS

VALVES as a source of noise and car trouble are discussed by the author, who defines perfect valve action as the complete, quiet closing of the valve at any speed and shows by sketches and description what is necessary to secure this.

Most emphasis is placed on misalignment of the valve-head with the valve-stem or valve-stem guide as the reason for 90 per cent of valve trouble, such as noisy operation, sticking valves and burned valves.

Misalignment is ascribed to slight distortion of the engine-block, the valve-stem guide and the valve seat due to seasoning of the cast iron as a result of the heat of combustion. Seasoned cylinders and valve guides are superior to new ones, but after the guides have become set in the first 1000 to 2000 miles of car operation, the valve-seats should be reconditioned as soon as possible if the engine shows such reconditioning to be needed; otherwise the failure of the valve to seat perfectly leaves a slight opening through which the burning gases rush at great velocity and burn the valve and warp the stem.

The relation of clearance between the valve-stem and its guide to wear of these parts and to noise and carbon deposition in the guide is discussed. Width and angle of valve faces are also considered.

Methods of reconditioning valves with machines for the purpose are described, and the use of replacement valve-seats and of valves with oversize stems is advocated.

The discussion consists mainly of questions asked and answers to them given by the author regarding the best angle of the faces of the valve and the valve-seat, use of special heat-resisting metals, mercury-cooled valves, alteration of the volumetric capacity of the combustion chamber, the best method of determining misalignment, and the like.

ELIMINATION of engine and chassis noises has been keeping pace with other progressive steps in the evolution of our automobiles into the powerful and smooth-running cars we have today. Few indeed, however, are the engines that can accumulate any great mileage in use without valve trouble, which is made evident by repeated visits to the service station to have the tappets adjusted and sticky valves freed or, in some cases, to have a burned valve replaced.

Valve trouble in most cars means lack of power; the engine will not idle, the car will not climb a hill as it used to do; some simple indication tells a man that his car needs the valves ground.

Perfect valve action is complete, quiet closing at any speed. To show what is necessary to secure this I have made some simple sketches that cover the principal causes of 90 per cent of the valve troubles that have been encountered ever since the advent of the automobile. At the left in Fig. 1, I have attempted to show a valve-seat in perfect alignment with the center line of a perfect valve-stem guide. The left-center drawing shows a perfect valve having the face concentric with the center line of the stem. At the right-center is drawn a valve with the head and face warped from the correct angle with the center line of the stem.

Assuming that the guide measures 0.375 in. in diameter and these two stems measure 0.374 in. each, the guide clearance is 0.001 in. This is as close a fit as will allow a valve to drop of its own weight in a hole or guide of this size. The valve at the right-center in Fig. 1 would not seat itself. The low side would strike and the valve would be held open on the opposite side. The valve at the left-center will seat perfectly, as its face will touch the entire circumference of the seat, and the valve does not require more than its own weight to seat itself. For the valve at the right-center to seat, it is necessary that the clearance between the stem and the guide be sufficient to permit the stem to assume an angle in the guide corresponding to the misalignment between the valve face and the valve-stem, as indicated at the extreme right in Fig. 1.

HOW WARPED VALVES PRODUCE NOISE

In the manufacture of valve mechanism in automobile plants, there has been much guesswork as to the clearance to give between the valve-stem and the valve-stem guide. Some plants give 0.0015-in. clearance on a new job; others as much as 0.0080 in. These clearances are given in the different plants, service stations and repair-shops to avoid the sticking of valves, without considering the loose fit as a source of noise, as well as the tappet adjustment and the valve-springs.

Whether the clearance is 0.0015 or 0.0100 in., the stem must have enough clearance in the guide to close through any eccentricity present. The spring pulls the stem sharply against the wall of the guide with a sharp metallic click, unless the clearance is excessive. The valve-spring on all automobiles is designed with just enough tension for closing the valve at top speed of the camshaft. It will travel or extend at only one given speed, according to its tension, but the camshaft has a variable speed. To illustrate, on a popular racing car in use today, a valve about 1 in. in diameter is used with a spring tension of 138 lb. At 6000 r.p.m. of the engine, the pressure between the push-rod and cam falls to ½ oz. and the valve barely closes before the cam comes around and begins opening it again. Consequently, if any unusual misalignment is present, not only are the engine speed and power reduced, but the warping and burning of the valves quickly send the car to the pits.

The valve we tried at first and used for many years

[1] Sales manager and field engineer, Willis-Jones Machine Co., Detroit.

was of cast iron. To mate the faces of the valve and the valve-seat, we used to grind the valve, putting abrasive compound between the two faces and sometimes grinding for hours. With the early engines, valve troubles did not cause much concern; other troubles overshadowed them. But with high-speed engines, warping and burning valves began to be noticed. Those troubles resulted in bringing out the steel valve, of which more than 100 makes are now in the market. Engineers at the car factories keep changing the makes they put in the engine in the hope of avoiding the warping and burning. They have done very little, however, with regard to the guide, the spring, or the seat.

Causes of Burned Valves

In most cases when an engine is taken down, it is found that only one or two valves are burned. If the metal in the valve were at fault, all the valves would burn under the same speed or heat conditions. When a valve does not close completely, the compressed burning gas, which reaches, under ordinary operating conditions, a temperature of 1500 to 2000 deg. fahr., is forced with great velocity through the small opening left and burns the valve face or warps the stem.

Were it possible to cut the valve-seat in perfect alignment with the guide and to cut the valve face true with the stem, we should not require more than 0.0015 in. clearance between the stem and the guide. Assume that the valve-seat and the valve-stem guide are perfectly true with each other and that the valve face is true with its stem when the engine is assembled at the factory; still the seats and guides are subject to seasoning, as is the case with all parts made of cast iron, and the intense heat generated in the automobile engine brings a rapid change in the texture of the metal and distorts these parts.

In the seasoning of cast iron, the metal becomes irregular in density and hardness, sometimes producing spots or portions that are many times harder than the surrounding metal. Should one or more of these hard spots appear in or near the surface of the valve-seat, the hammer-like blows of the valve will tend to produce faster wear in the softer metal at the opposite side of the seat.

Although the seasoning and resultant warping of cast iron starts with the cooling of the casting in the foundry, this action continues indefinitely but diminishes slowly with age or use. The valve-stem guides sometimes require from 1000 to 2000 miles of running before they have become permanently set or seasoned. Thus, every hour's operation of the engine adds to the value of the material in these parts, but makes it necessary to service or recondition the valve-seats as soon as possible after the engine shows such reconditioning to be needed.

Valve-Stem Guide Loses Its Alignment

The guide, a small cast-iron member held by less than 50 per cent of its own length and extending, as it does, into the valve port where the heat from the burning gas has greater opportunity to warp it, soon loses its perfect alignment with the seat and changes the direction of travel of the valve. The spring has the power to close the valve regardless of this untrue condition, but does so through a second unnecessary movement, the valve striking a small portion of the seat first and then gaining the full seat through a pendulum-like swing of the stem. This produces a metallic click that defies removal through cutting the tappet clearance.

Sticking valves are produced through the same misalignment. Fifty thousand to 100,000 times a day the valve is opened and closed in the normal running of an automobile. Under the best conditions, this side-slap of the stem will produce carbon to such an extent that it will seal the valve-stem in its guide regardless of the amount of clearance, so that in some cases it becomes necessary to use a crowbar to get the valve out of the guide. It has been thought that most of this sticking was caused by the peening on the end of the stem, and this has been ground off and the valve put back without taking the carbon out. The carbon, however, added to the misalignment because it packed one side of the guide more than on the other. In too many cases hand pilots have been used to cut the seat in line with the bore of the carbon and not with that of the guide.

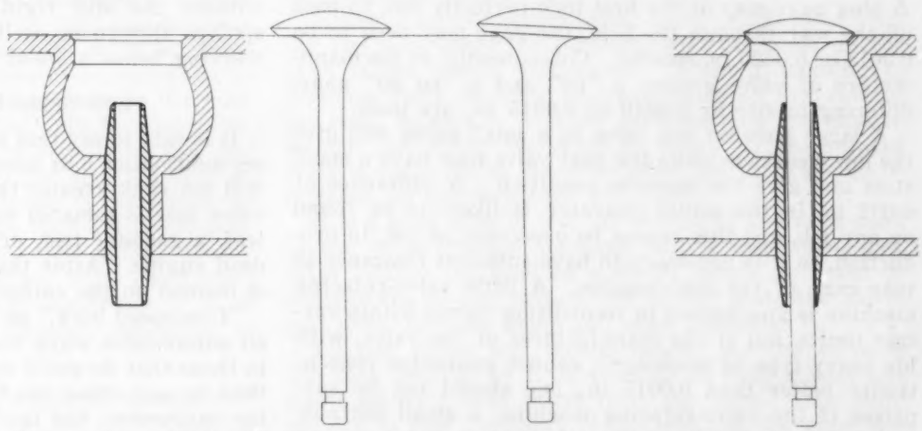

Fig. 1—Valve-Seat, Perfect and Warped-Head Valves, and Valve-Guide Having Excessive Clearance Needed to Enable a Misaligned Valve To Seat Itself Completely

The Valve-Seat at the Left Is in Perfect Alignment with the Center Line of a Perfect Valve-Stem Guide. The Left-Center Drawing Shows a Perfect Valve Whose Face Is Concentric with the Center Line of Its Stem. At the Right Center Is a Valve Having a Warped Head That Cannot Seat Properly on the Valve-Seat Unless Excessive Clearance Is Provided in the Valve-Stem Guide, as Shown at the Extreme Right. This Excessive Clearance, Combined with the Action of the Valve-Spring, Results in a Clicking of the Stem against the Side of the Guide When the Valve Seats

Stem Inaccuracies and Guide Clearance

Throughout the years of progress in the development of the internal-combustion engine the valve has received more than passing attention of the engineer and others in the motor-car industry but the valve-seats, guides and springs have, in most cases, been neglected. If the engineer wanted higher speed he enlarged the valve and gave the spring more tension. Guide clearance was, and is, mostly a matter of personal opinion.

Guide clearance depends upon the accuracy with which the job as a whole is built. If a valve-seat is absolutely square with the valve-stem and the valve face is perfectly concentric with the stem, the valve will not need grinding; it will need nothing but a spring of proper tension. When such a spring has been put on, the engine can be started with assurance of perfect valve action. No more than 0.0010 or 0.0015-in. clearance will be necessary so long as these parts retain such accuracy.

No valve manufacturer will take a contract today to furnish valves with accuracy greater than 0.0015-in. concentricity of face with stem, or 0.0005 in. plus or minus on the stem size. It is impossible, with any reamer one can buy, to ream the guides with any assurance of two holes giving the same stem clearance. If a hard spot is struck near the top, the taper on the reamer will cause the reamer to go in at an angle for awhile. A plug gage may fit the first inch perfectly but, to pass all the way through the hole, the gage may need to be 0.0015 or 0.0020 in. smaller. Consequently, in the manufacture of valve guides, a "go" and a "no go" gage, differing in size by 0.0010 or 0.0015 in., are used.

A large stem on one valve in a small guide will give the low clearance while the next valve may have a small stem and give the opposite condition. A difference of 0.002 in. in the actual clearance is likely to be found on any job, and this cannot be overcome, as yet, in production, so it is necessary to have sufficient clearance to take care of the inaccuracies. A little valve-refacing machine is guaranteed to recondition valves within certain limits, but if the manufacturer of the valve, with his heavy type of machinery, cannot guarantee concentricity better than 0.0015 in., one should not be surprised if the valve-refacing machine, a small portable tool, will not cut closer than that.

Although any good valve-spring having a tension of 50 lb. or more will perform its work perfectly at low or normal engine-speeds, it is necessary with any valve-spring to put so much resistance into it to completely close the valve at the maximum speed of the camshaft that at lower speeds the power exerted will close the valve through any normal amount of misalignment.

Experiments made recently at a motor-car factory have resulted in the development of a new double spring. Through the help of K. T. Brown[2], I was afforded an opportunity to see the test room where one of the engineers was using a machine called the strosboscope, which enables the engineer to observe the movements of valve-springs accurately. This was set to watch the action of the valve-spring in actual engine operation. A cam was driven by an electric motor, as perfect a valve as the company could make was in place in a guide of the regular length, the seat was perfect with the guide, and the valve-stem and guide had a total clearance of 0.004 in. All kinds of valve-springs were tried, and one of the most remarkable facts noted was that one theory of many automobile men, that valves bounce on the seat, was refuted. They do not bounce unless the spring is weak. Only one valve-spring permitted the valve to bounce on its seat, and that spring had its two ends out of parallel more than ⅛ in. and had only 40-lb. tension.

However, all springs put through their paces for me showed a distinct oscillation. After the valve gained its seat, the coils continued to move up and down, not striking each other, however, until a speed equivalent to a car speed of 35 or 40 m.p.h. was reached. The single-coil springs had a weaving action also at 50 to 60 m.p.h. Only the spring with the ends so far out of parallel swung the valve-stem enough at 35 m.p.h. to permit the stem end a maximum movement of 0.002 in. in each direction from center, with only 0.004-in. clearance in the guide. So it was shown that the valve-springs do not produce the noise at idling speed that many of us have thought in the past.

Most of us have turned a spring around or put in a new one and stopped a valve noise. Misalignment of the valve and its seat with the guide was the cause of the noise, and this was corrected by the turning of the valve. The company to which I have referred is using two intercoiled springs of 50 per cent less tension than a single spring, which permit of more resilient action without the stiff rigid closing at low speeds. These springs showed no oscillation or spring chatter and no weaving below a speed of 80 m.p.h.

"Low-Speed Buck" and Its Cause

It is safe to say that 90 per cent of the so-called valve-reconditioning jobs done by the garage and service man will not rank greater than 50 per cent of perfect. The valve face is remated with its seat, as proved by a blue test, a gasoline test, or by perfect compression on the dead engine. After that, if anything is still wrong, it is blamed on the carbureter or on the ignition.

"Low-speed buck," as we call it, does not develop with all automobiles when they lose perfect valve action, but in those that do get it more grief and expense is caused than by any other one thing. It has been blamed upon the carbureter, the ignition, the universal-joints, slack in the transmission, the differential gears, and even upon the spring shackles, and we have records showing that as much as $500 has been spent on a single automobile to cure low-speed buck.

After the valves have been ground on two automobiles of the same make that have run the same mileage, one will perform perfectly and the other will have low-speed buck. Why? If on every cylinder of the one job the valves are within 0.002 or 0.003 in. of perfect alignment, there will be no power loss through the valves at normal speed or more, say above 40 to 50 m.p.h.; but, if there is a serious misalignment on one or two cylinders of the other car, we can get the same perfect blue test and perfect compression test, yet at 10 m.p.h., when the load is greatest on the engine, the slower complete closing of the valve which weakens the compression of that one cylinder will result in low-speed buck.

In many cases we have been working on the idea that the valve was at fault, when it was the valve-seat and guide. They are just as important as the valve and are more easily disturbed and damaged. It has been learned through extreme adversity that the valve face must be true with its stem, and we have therefore developed valve-refacing machines to make the work of remating the valves with their seats easier and to save the cost of new valves.

It is impossible, when a valve-guide warps and loses its original alignment with the block and the valve-seat, to bring it back, yet it is ridiculous to replace it. From 1000 to 2000 miles of operation is needed to season the cast-iron guide and the cylinders thoroughly. We learned that long ago. Years ago motor-car manufac-

[2] M.S.A.E.—General service manager, Packard Motor Car Co. of Boston, Boston.

turers refused to allow us to put in an oversize piston and warned against oversizing the cylinders. Today they furnish their dealers and repair-stations with oversize pistons, practically all of the industry now recognizing that the cylinder, in seasoning, becomes much more valuable than it was when new. The first 10,000 to 15,000 miles of operation of any engine makes the set of cylinders worth a dozen new ones, so far as warpage is concerned. On most of them warpage of 0.005 to 0.015 in. occurs in 15,000 miles of running. After reconditioning the cylinders and running the engine for the same distance again, the warpage will be very little. The little valve-guide, then, is imperfect until it has warped and settled. We must then cut the valve-seat true to the new angle that the guide has taken to remedy the condition.

Car manufacturers have also tried to discourage the use of valves with oversize stems. At that time the only tool available for use on valve-guides was a reamer having a tapered end starting from the standard-size valve-guide and quickly increasing to 0.015-in. oversize, the only oversize valve we have ever considered or had. All that could be done was to enlarge the hole. A reamer is designed and intended only for enlarging, not for truing. The car companies recognized this and supplied only standard valves. They also felt that to furnish oversize valves would make it necessary to carry too many sizes in stock. So they did it the easiest way and sold the customers a new guide. Today there are, I think, seven factories that recommend the use of oversize valves, because equipment is to be had for oversizing the guides correctly according to mechanical principles.

Hard Spots Cause Cutter Chatter-Marks

If one must cut a seat in metal that contains different degrees of hardness, the cut will show slight chatter marks if examined closely. It is impossible to prevent these chatter marks. When the cutter reaches the hard spots, regardless of the weight of the tool, it will first slow down and then speed up as it gets through the hard spots, pulling the softer metal beyond or forcing the cutter away. If, after cutting the seat as perfectly as possible, an attempt is made to grind it, the grinding compound is resisted by the hard spot and the seat is ground into further misalignment because of the softer metal opposite taking the grinding far faster than the hard spot.

It is sometimes said that it is foolish to cut away the scale when recutting the valve-seat, as it has been a long time in arriving at the condition of a glazed, hard surface. However, if cutting is done with compound and with the valve only, the scale is being cut and it is not known whether the alignment is being corrected. If the seat is being cut before grinding, all scale must be removed from the full surface; otherwise a hard, glazed spot will be left that will resist the pounding of the valve while permitting the soft metal on the opposite side to be pounded into misalignment.

Much difference of opinion exists as to the proper width of the valve-seat face. Some motor-cars have a seat width of 1/64 in. and some have about 5/32 in. The best width of seat that I have found in my work is about 3/32 in. The seat should not be less than 3/32 in. on the smaller valves. In re-cutting the valve-seat, all scale and glaze is removed and the surface is left furred or soft. If the seat is too narrow, the hammer-like blows of the valve will easily pound this down, constantly changing the tappet clearance.

When Valves Should Be Replaced

Upon removing valves for grinding, and after cleaning carbon from the valve and stem and checking the stem for wear, it should be remembered that, if the guide shows 0.002-in. wear, a new valve-stem would have a possible 0.006 or 0.007-in. clearance. To prevent possible leakage of the exhaust and imperfect carburetion, the valve-stem should not show wear in excess of 0.003 in. It is not the amount of wear on either the stem or the guide that gives trouble, but the excessive clearance that would result in wear showing in both units; therefore, through the aid of plus pilots, we must check the guide size and replace the valves if the old stem shows that clearance will be greater than 0.008 in., or must rebore the guide and use new valves with oversize stems.

It should also be remembered, when chucking or holding the valve-stem for refacing, that the wear on the stem is not evenly distributed. When attempting to reface a valve showing excessive wear on one side of the stem, be sure to hold the valve-stem by the unworn section just above the point of wear. If the refaced valve is very thin at the outer edge, the valve should be replaced, as the thin edge will burn.

It is a good plan to test the setting of the work-head of the valve-refacing machine with a new valve and, after locking the head on a 45-deg. angle, to grind or sharpen the 45-deg. seat-cutters so that seats and valves will have the same angle and mate perfectly.

Do not, under any circumstances, lap the valve to the seat heavily, as it is possible to ruin a seat and never secure a true result from the work. Only light lapping is ever necessary if the seat and the guide are true with each other and the valve face is true with the stem, and then only to remove slight chatter marks. Should any blank spots appear on the valve, this would show faulty refacing and the valve-refacing machine should be corrected. Should blank spots appear on the seat, the tool should be set up and checked with a new cut with the 45-deg. cutter, making sure that a complete circle is cut before disturbing or removing the cutter.

Treatment for Worn Rocker-Arms

On all makes of poppet-valve engines there are a great many noise-producing parts and all must be checked if perfect valve work is wanted. In the case of one engine which had a double spring, the spring-retaining thimble was the least bit bent and caused the center spring to touch the outer spring in passing. This engine was worked on for about 2 weeks before the cause of the trouble was found.

With automobiles having valve-in-head engines there are more points for difficulty than with the T-head or L-head engine, one being the rocker-arm. It will be found upon examination that the rocker-arm shows wear where contact with the valve-stem end is made. Sometimes the wear is crescent shaped and sometimes forms a complete circle. In reassembling the parts, the same alignment of the valve cannot be secured; the valve-stem is likely to strike on the edge of this worn section and the valve to go through a second motion in closing. A shim cannot be inserted with any degree of accuracy and therefore more noise is produced. The only solution is to regrind the rocker-arm.

There must be, in the rocker-arm bearing, at least 0.003-in. clearance on the shaft size. It must be free; clearance there will not produce a noise. A clearance of 0.001 in. will cause 10 times as loud a noise as 0.005 in. The oil film will cushion the blow if there is enough clearance; but if, for any reason, the fit is too tight the valve will strike on one side and the cam or the push-rod on the opposite one.

If the end of the stem is reground square to the center and the rocker-arm is not square with the valve alignment, it will strike on one sharp edge. However, a V-block is furnished in all valve-refacing equipment and, if one end of that is raised about 0.002 in. from square and the valve-stem is revolved rapidly with the end against the side of the stone, a slight bevel will be produced on the end of the stem. This will permit of more accurate adjustment, and all valves will be easily set to the same tappet clearance.

The Use of Replacement Valve-Seats

Through too stiff a spring action or too soft metal in the casting, sometimes aided by the misguided efforts of the mechanic, valve-seats become so wide and displaced so far below their normal position in relation to the face of the block that results detrimental to perfect valve action follow, sometimes destroying the cylinder-heads and blocks. Many repair-shops and service-stations today are using some type of tool for installing new valve-seats. These tools can be obtained for virtually all makes of poppet-valve engine.

In developing a replacement seat it was necessary to use a metal that would not shrink and become loosened in the counterbore, that was tough enough to withstand driving into place, and that was hard enough to withstand the hammer-blows of the valves, so we may expect to get better service and longer life from the replacement seat than from the original seat cut in the surface of the block. When the replacement seat does become worn or pounded down, it is easy to remove it and install another in its place.

Today, the sales division of a motor-car company must not only deliver a product that reflects the dollars invested in it by the purchaser but must make every effort to keep the purchaser satisfied that his choice of an automobile was not wrongly placed. Only well-equipped service-stations are able to do this. With the aid of tools and equipment developed from methods or ideas used before, and brought to present-day perfection for faster or more accurate work, or both, they can recondition virtually all parts of the motor-car with positive assurance that the work will bear rigid inspection and prove satisfactory. Most of the car manufacturers are maintaining schools or service clinics for the education of the mechanic in the use of equipment.

THE DISCUSSION

QUESTION:—If a valve-head has been warped at the side, how many thousandths of an inch is it advisable to rectify that by regrinding? A badly warped valve would be out of balance if reground.

JACK FROST:—No definite amount of warpage would make a valve unfit for use if the stem were straight, and regrinding of the face should correct the misalignment. I do not think the balance would affect the running of the engine. However, if one portion is ground enough to produce a sharp thin edge, this will permit quicker acceptance of heat and possibly a burned valve.

QUESTION:—Are you committed to the advantage of the conical over the flat seat?

MR. FROST:—The degree of the angle on the valve face is entirely a matter of personal opinion among engineers. No motor-car builder with any experience will go to less than 30 deg. toward the flat valve. Most manufacturers use 45 deg., for the simple reason that a 45-deg. angle is like two funnels, one nesting within the other. Therefore, less spring weight is required than is needed to hold two flat surfaces tightly enough together to hold air or gas.

QUESTION:—What effect has the width of the valve face on the temperature of the valve?

MR. FROST:—Cooling of the valve is accomplished in two ways: by a water-cooled jacket around the valve-guide and by the momentary touch of the valve-head against the seat. The greater the width of the seat is, however, the greater is the possibility of inaccuracy. The greatest heat is in the center of the valve-head and it is distributed in all directions and travels down the stem of the valve.

Cooling of the intake valve never has been a problem, as the incoming gas cools it, but cooling of the exhaust valve has always been one, and one of the faults is the cutting of the seats below the surface of the block. The lower the exhaust valve is, the less cooling it gets from the rush of the charge of cool gas across it when the intake valve opens. The higher it is, the more cooling it gets. So, in reconditioning, the valve should not be allowed to go too far below the surface of the block.

We made some recent experiments when putting in replacement seats, raising the seat in some cases as much as 1/16 in. The valves remained quiet and the engine had far greater acceleration than with the regular seat. We believe that is because the incoming gas keeps that head cool.

QUESTION:—If the face of the valve is burned off, is the only remedy to put in a new valve?

MR. FROST:—No, the valve is not harmed in any way by burning; only a certain amount of its life is destroyed. We have never found, in any of our experimental work, that any trouble was caused through burning the valve face only.

Double Gasket Reduces Compression

VALDEMAR A. NIELSEN[3]:—Would the raised seats increase compression? Should a double gasket be used?

MR. FROST:—I would not put on a double gasket. I have tried it on Dodge and Hudson cars and it has been tried on others. We never used an extra gasket, because a double gasket would give more compression space, thus cutting the actual compression far more than the amount of metal contained in the replacement seat would increase it. The metal added in the compression space gives a slightly higher compression but does not raise it so much as to be troublesome.

[3] M.S.A.E.—Treasurer, engineer, V. A. Nielsen Co., Boston.

MR. NIELSEN:—Regarding the angularity of seats, one manufacturer recommends, in his manual for mechanics, the cutting of valve faces to 43 deg. and the cutting of the seat faces to 45 deg.

MR. FROST:—I can see no reason for changing from 45 deg. on both. No one knows that the angle is exactly 45 deg. unless he has a machine set on a 45-deg. angle that cannot be changed. Cutting the seat and valve faces to different angles will not give any advantage. The force of the blow of the closing valve will come on 50 per cent of the face, or less. One might as well cut a narrow seat.

A GUEST:—You explained how a valve out of alignment might form an untrue seat. In the case of an engine tested with a cylinder pressure-gage, the compression showed that the seat was all right, for when the engine was turned over slowly the compression would be good, yet the engine would skip at low speed. Would that be more noticeable at high speed than at low speed?

MR. FROST:—A complete misfire in a clyinder cannot be found at 60 m.p.h. The weight of the car and of the mechanical parts will carry over the lapse. However, misalignment that would produce low-speed buck is not always enough to be noticeable at starting engine-speed. If the test is made at starting speed, the skip will not be found. Misalignment is not always the direct cause of the trouble, but to avoid noise the tappets are sometimes set too close and the valves somethimes burn for this reason.

A GUEST:—If compression is perfect at low speed, should the engine run all right?

MR. FROST:—Yes, because the greatest load is on the engine at 10 m.p.h.

How Misalignment Results in Burning

A GUEST:—Do more valve-reconditioning jobs result from the use of ethyl gasoline, which has a tendency to burn faster?

MR. FROST:—Yes, because we are unable to get perfect alignment and in only a few cases is an attempt made to get it, and, as the combustion is a little hotter, it burns the valves at lower speeds than fuel that burns at a lower temperature.

A GUEST:—Do not these new silchrome valves take care of that?

MR. FROST:—Not any more than any other valve, if there is any misalignment of the valves. They will not withstand 2600 deg. of heat against the stem just under the head. They will resist much more heat on top of the head, but the valve must be perfectly seated to protect the part which first shows warpage. The difference in size and weight of the head and stem metal permits warpage of the stem, thus raising the valve on one side and starting that part toward destruction.

QUESTION:—Why is it that several large manufacturers in this Country and in foreign countries, who have facilities for using the best and are willing to try anything in the way of aligning tools in building high-powered, high-speed engines, find it necessary to use a mercury valve for the dissipation of heat?

MR. FROST:—They are using them only in an experimental way. The valve is too expensive for motor-car production purposes, but the airplane people are doing considerable experimenting with it.

QUESTION:—Why do all of the large manufacturers of aircraft in this Country find it necessary to use the mercury valve to keep the seat from warping? Is alignment the whole worry in keeping the valve-head in condition?

MR. FROST:—All I can say is that the makers claim that they are now using almost as many new cylinders as new valves, to get new valve-seats. Four airports in the West are putting replacement seats in their aircraft, and are having as many burned valves with mercury valves as they ever had with any other kind.

MR. NIELSEN:—There is no question in my mind that if I take a mercury valve, a silchrome valve or any other, to a burning outfit, I can deliberately burn a section out of it. The provision for cooling or the heat resistance of the metal may delay the action for a long time, but ultimately, due to compression, heat, and the small opening that is provided, because the valve does not seat perfectly, the valve will burn.

Temperature Differences Cause Seat Distortion

QUESTION:—Is it not a fact that a considerable percentage of the misalignment is caused by the valve-seat itself distorting because of the heat?

MR. FROST:—In any engine there is $\frac{3}{8}$ in. of metal between the valve port and the cylinder-wall. In one place we have nearly 2 in. thickness; in another $\frac{5}{8}$ in. There are irregular amounts of metal around the valve ports. There is water-cooling around some parts and not around other sections. An intake valve, with cooling gas coming in, is next to an exhaust valve. Consequently, the seats will distort and go out of round.

QUESTION:—Do you not believe that there is considerable difference in the material put into valves with regard to the time it takes to burn them?

MR. FROST:—Different degrees of heat are required to burn different steels, whether in valves or in anything else. High-grade steel will last longer than low-grade steel or cast iron, under the same heat conditions, but if the valve is misaligned the kind of material used would not lessen the burning.

QUESTION:—Will the seats burn more quickly on an engine that has had the cylinders repaired or reconditioned and the compression space increased than on a standard engine?

MR. FROST:—The increased bore and compression space should not affect the valve in any way. We have tested jobs with valves in perfect alignment, driving the cars for 4 or 5 hr. at top speed of the engine, and have not burned a valve. With either the former bore or the enlarged bore, the valves would have burned if the engine had been run an hour at top speed and the valves were not seating correctly. Burning is caused only by the escape of burning gas between the valve face and the valve-seat. It is not due to compression or to the type of gasoline used.

QUESTION:—In some of our blocks we have more slugs or hard spots in the iron than in others. How will the replacement seat work in expansion of the tools?

MR. FROST:—That never has troubled us to date. We drive the replacement seats in with a 0.005-in. driving fit.

Why Worry Over Change from Standard?

A MEMBER:—You said that changing the valve-guide is a fallacy, but the usual argument against putting in an oversize valve is that the engine is no longer standard.

MR. FROST:—Naturally, if the guides are rebored and a valve with an oversize stem is put in, we are getting away from the maker's standard sizes, but how many engines, by the time the guides should be restored, still have the original pistons, pins and rings? One thinks nothing of replacing any of these parts with oversizes. The majority of parts jobbers handling valves have long carried the two sizes, standard and 0.015-in. oversize. Some motor-car manufacturers also are now supplying these oversize valves to their dealers.

If the valve-seats are trued early in the life of the engine, as soon as inaccuracies arise, abnormal wear will be prevented and the guides will last longer. They last today for 30,000 to 40,000 miles. If 10,000 or 25,000 miles more can be added, why worry about putting in a 0.015-in. oversize valve?

THE TEST FOR MISALIGNMENT

QUESTION:—What is the best way to test for a misaligned condition of the valve and seat?

MR. FROST:—The best way is to revolve the valve for only a few seconds, touching it lightly with light compound. If it shows gray on one side, that is a sign of misalignment, but if it shows gray in several places it means that the valve-refacing machine is out badly in the chuck bearing. If there are even-spaced machine marks showing gray with that light touch, they indicate a chatter and that the stone has worn down to too small a diameter or that it is rough or that the belt is slipping and the speed is not correct.

Regardless of the condition of the valve, as it has turned a complete circle in the seat, it will touch the seat all around. If there are blank spots in the seat, examine them. If just one blank spot shows, it indicates that a perfect cut has not been made; the tool has not been locked perfectly or is not traveling perfectly, or the cutter is ground wrong, or something of the kind.

I might mention for the benefit of some service men who will have to work on the new Model-A Ford, that there is only one tool on the market today with which the valves can be ground. The valves have a smooth top with no holes or slots. If the factory is using that tool in the production line, it will have to be used in the service stations.

SHOULD MAKE TESTS DURING RECONDITIONING

QUESTION:—How can the Ford valve, with the button on the end, be ground?

MR. FROST:—That little button has caused a lot of worry. I have heard representatives of two valve-refacing-tool manufacturers say that their machines will do it. One machine has a ½-in. chuck mounted on a hollow bearing. It can also be done with a ½-in. collet that will come down to 5/16 in., putting the button on through the collet.

It should always be remembered that, in doing a reconditioning job, one must make tests of the work. The time to make them is while the valves and their seats are exposed. There is equipment on the market for everything of that sort.

QUESTION:—On a certain car which has been troubled with sticking of the exhaust valve, the manufacturers recommend counterboring the valve-guide. Is that, in your opinion, good practice?

MR. FROST:—The guide is there as a bearing. When it is counterbored for ½ or ⅝ in., just that much bearing surface is taken away. The makers thought that carbon at the top of the guide was catching on the stem and holding the valve. In most cases, I find the hardest and the greatest amount of carbon down in the center of the guide, not at the top.

QUESTION:—What do you think of graphite alignment guides?

MR. FROST:—Graphite will resist only a certain amount of heat before burning, and it does not prevent oil from packing carbon; neither will it prevent distortion and misalignment.

QUESTION:—What about the spiral that is supposed to take care of the oil?

MR. FROST:—It will not take long to fill that spiral with carbon, just as piston-ring grooves become carbon-filled.

Cost of Airplane Operation

THE three important factors that make up the present-day cost of airplane operation are overhead, insurance and depreciation and obsolescence. Obviously, since airplanes today carry only a handful of passengers, this overhead expense is bound to be disproportionately high. As the volume of business increases, the figures for overhead will be in better proportion to the revenue.

Insurance is one of the outstanding problems of the commercial aviator. The present almost prohibitive insurance rates will be slashed when the public and the insurance companies learn to differentiate between the risks involved in passenger air-transport and in the other more spectacular and non-commercial phases of aviation.

The major cost of airplane operation, however, is depreciation and obsolescence. Although there is little accurate knowledge of the depreciation rate of modern airplanes, nevertheless at the present time every capable airplane operator writes off his equipment over a period of between 2 and 3 years. With the lightning-like changes that are taking place in the airplane, the conservative operator will anticipate a revolutionary alteration in his equipment at the end of between 2 and 3 years.

In considering the economic factors of air transport, one should not overlook the opportunity of operating small units, which has the obvious advantage of small initial capital expenditure and permits a gradual expansion as business justifies. On the whole, therefore, future costs of airplane operation will compare favorably with the cost of other forms of transportation.—Harry F. Guggenheim before New York Railroad Club.

Power Brakes for Passenger-Cars

By H. D. Hukill[1]

New England Section Paper — *Illustrated with* Photographs, Drawings and Chart

THE use of a power medium in brake control points at once to the possibility of simplifying the brake system so that its characteristics, once established, can be expected to remain uniformly effective throughout extended periods without adjusting, with correspondingly long life of brake-linings. The author says also that, if the greater retarding effect possible with mechanically operated four-wheel brakes is to be fully realized, it is necessary to do one of three things: increase the pedal pressure, increase the brake leverage and consequently the pedal movement, or increase the "self-energizing" effect.

The vacuum-type brake described is stated to be an amplifier which provides power to supplement muscular strength and assists the driver to apply the service brake, thereby reducing the required pedal stroke and pedal pressure without interfering with the regular service-brake hook-up. The description is illustrated with a drawing on which the parts are lettered for reference so that their operation and the way in which the forces are amplified can be understood readily. The capacity of the various vacuum brake-units manufactured by the company represented by the author is stated, and a chart is presented which shows graphically, for each size of unit, the pull it can develop on the brake-rod either with or without the assistance of the amplifying device.

Discussion of the paper includes a comparison of the brake-pedal force required for two-wheel and for four-wheel brakes, assuming that the lever ratios and the general foundation of the brake design remain undisturbed; statements of the amount of vacuum that can be depended upon to operate the brake unit; and an explanation of the effect on carburetion resulting from the air that is admitted to the intake manifold at the time of brake application.

THE automotive industry has long concerned itself with the development of methods and appliances to make motor-car driving safe. Four-wheel brakes were a significant step in this direction in that they distributed available pedal-pressure over all four wheels, but the force available to operate the brakes on all four wheels remained the same as before; that is, muscular effort of the driver.

If the greater retarding effect possible with mechanically operated four-wheel brakes is to be fully realized, it is necessary to do one of three things; (*a*) increase the pedal pressure, (*b*) increase the brake leverage, and consequently the pedal movement, or (*c*) increase the "self-energizing" effect. Obviously, increased pedal pressure is undesirable; but, if twice the braking result is to be had, it will be necessary to apply twice as much effort to four-wheel brakes as to two-wheel brakes.

To keep down the pedal pressure required to control a car, it has been necessary in many cases to increase the brake leverage to such an extent that the pedal movement is awkward and difficult, especially when the foot has to be lifted 7 or 8 in. from the accelerator to make contact with the brake-pedal. In the effort to counteract this long pedal-movement, the practice of using close-fitting brake-bands or expanding brake-shoes has sometimes been resorted to, with the result that the slightest wear makes frequent adjustment necessary, and that brake-bands often burn out as a result of brake-drum expansion. It is also sometimes necessary to take full advantage of the cumulative effect of

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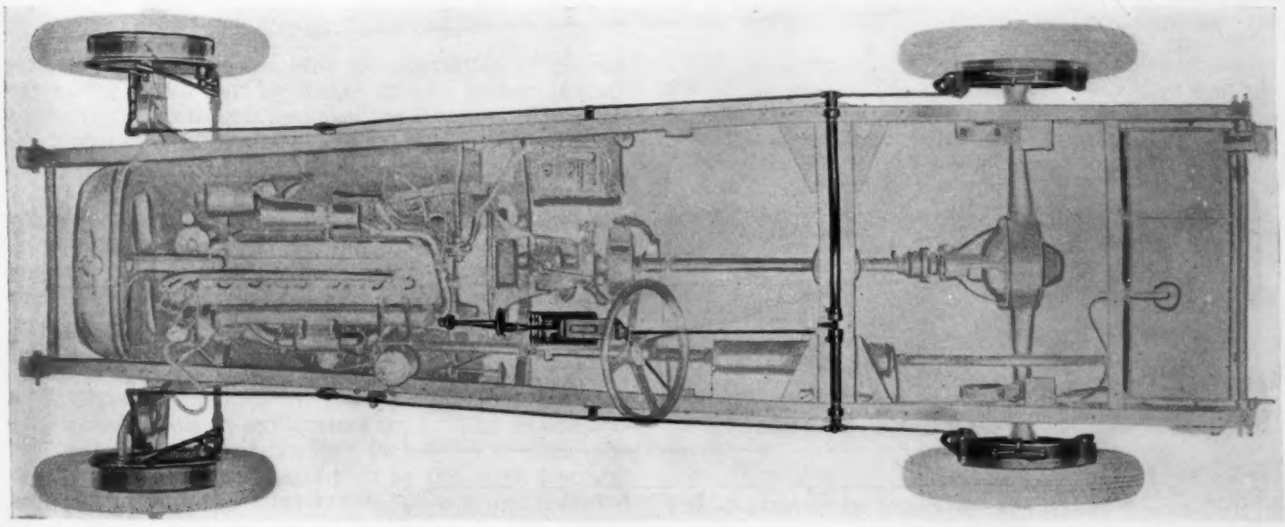


Fig. 1—Passenger-Car Chassis, Showing Vacuum Brake-Unit

the wrapping tendency to obtain sufficient retarding force. This is undesirable, as it increases the possibility of brake grabbing and decreases the brake efficiency during backward movement.

It seems appropriate, at this point, to contrast the fundamental characteristics underlying present braking practices and the promise of power braking. Considerable activity now exists in a search for whatever assistance can be obtained from the use of "wrap-up" or "self-energizing" features which, for the most part, require rather accurate adjustment and skilled maintenance to be and to remain fully effective, presenting at the same time a rather serious service problem to produce proper operation after relining in the field. The use of a power medium in brake control points at once to the possibility of simplifying the brake system so that its characteristics, once established, can be expected to remain uniformly effective throughout extended periods between adjustment, with correspondingly long life of brake-linings. Vacuum brakes have already been very favorably received in Europe, as is made evident by the fact that they have been adopted as factory equipment by 65 European manufacturers.

Vacuum Type of Brake

The Westinghouse vacuum-type brake is an amplifier. It provides power to supplement muscular strength. It assists the driver to apply the service brake, and thereby reduces the required pedal-stroke and pedal pressure without interfering in any way with the regular service-brake hook-up. The pedal pressures, although but one-third those normally required, are sufficient to retain the "feel" of braking; a proportionate amount of pedal pressure with corresponding movement will give a proportionate amount of braking effect. This assures safe car-control under all conditions, with almost no physical effort.

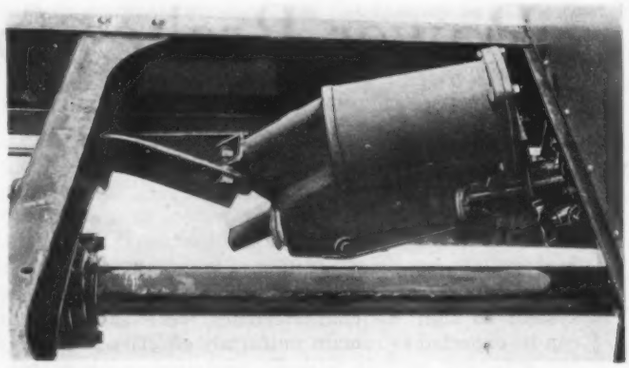


Fig. 3—Vacuum Brake-Unit Applied to a Motor-Truck

So long as the driver maintains a certain pressure on the pedal, the braking force remains constant. As soon as he lessens the pedal pressure, the braking force becomes proportionately less, and as soon as he increases the pressure the braking force correspondingly increases. He can, therefore, at all times feel the degree of braking, since this depends entirely on the pressure he exerts on the pedal. The power of the vacuum am-

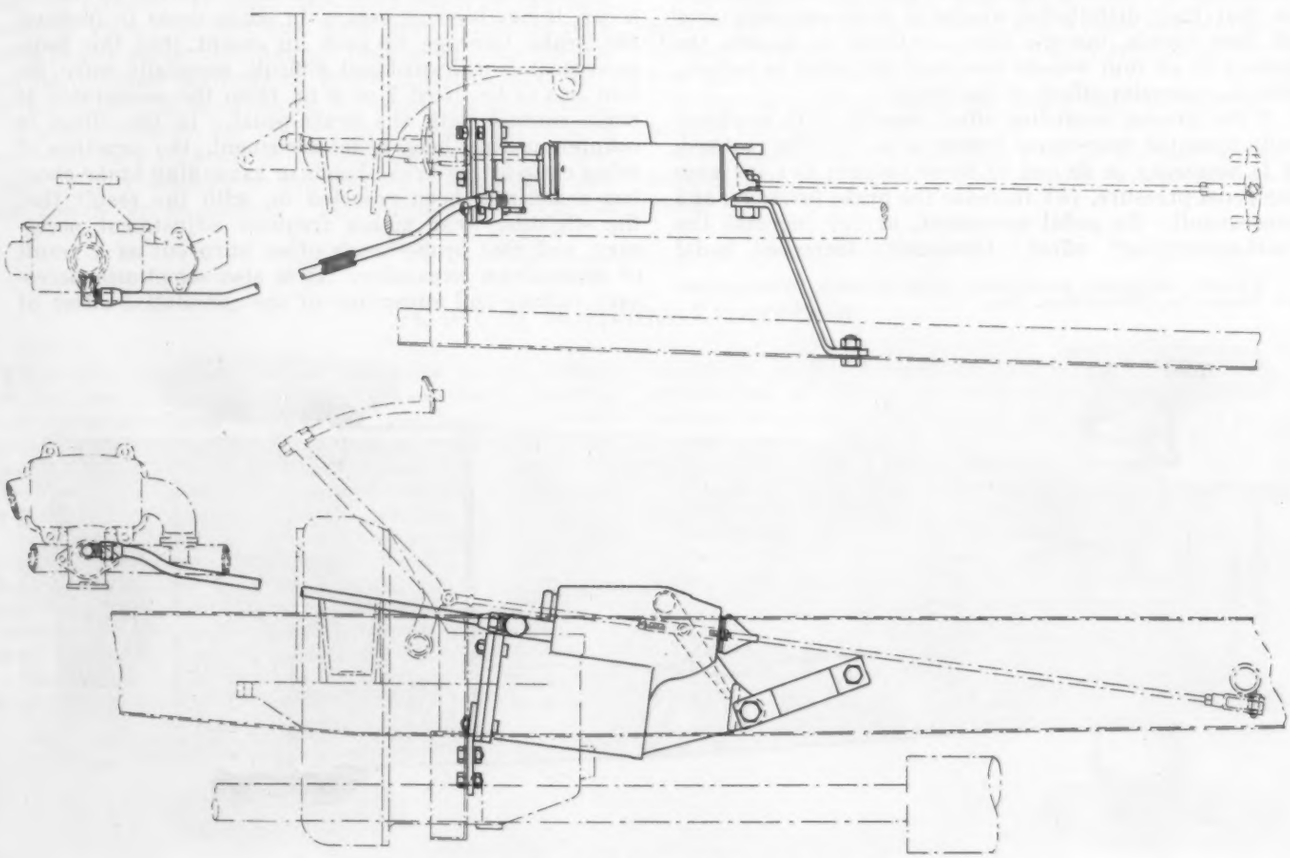


Fig. 2—Vacuum Brake-Unit Applied to a Passenger-Car

plifier assists in each instance the muscular effort of the driver, and in the proportion desired, affording perfect graduation and very smooth stops. Brake operation with such light pedal-pressures quickly becomes an act of unconscious judgment and imparts a new feeling of confidence in car control in traffic and on slippery streets. It removes, as well, virtually the last existing really laborious factor in modern motor-car operation.

The brake amplifier is a compact self-contained device attached rigidly to the chassis between the brake-pedal and the standard brake-mechanism, as shown in Fig. 1. Fig. 2 shows an installation drawing of the unit applied to a passenger-car, and Fig. 3 shows a larger unit applied to a truck. The unit can be installed on many cars simply by cutting the rod connecting the brake-pedal to the first equalizer or cross-shaft and inserting the device, restoring the connection of the cut rod to the brake unit by means of two yokes. As an amplifier for hydraulic systems, the leverage system of the brake unit is reversed and transmits the force to the master cylinder by pushing through the amplifier, with the short brake-rods in compression. The original braking system is left intact, so that the brakes can at all times be applied by the physical force of the operator with or without the assistance of the amplifier. Should the vacuum fail for any reason, the brakes can be applied by foot pressure alone without any added resistance from the vacuum unit.

The brake unit is comprised of an operating piston, a simple valve-mechanism, and an ingenious leverage system, as shown in section in Fig. 4. The double-acting operating-valve of the unit includes a vacuum connection and an atmospheric port to the main housing, so that, through the valve action, air can be exhausted from the cylinder proper or be ported to the atmosphere. The housing is fitted with a breather and a suitable curled-hair strainer to prevent the admission of road dirt and splashings.

Referring to Fig. 5, it will be seen that a rod, *a*, extends from the regular pedal to a double-armed lever, *b*, which has a floating fulcrum at *c* on the single-armed lever, *d*, which is in turn fulcrumed on pin *e* in the upper part of the housing. Lever *b* is formed with an eye at its upper end which surrounds the pin *e*. This eye is of somewhat larger diameter than the pin itself, to give lever *b* a certain freedom of motion around the floating fulcrum *c*. From the eye of lever *b* a rod, *f*, connects through rocker-arm *g* to the two poppet-valves, *h* and *i*.

If the driver presses lightly on the pedal, the effect will be to rock lever *b* left-handedly around floating fulcrum *c*. Rod *f* will then be moved toward the left, the direction of motion being changed by rocker-arm *g*, and the application valve *h* will be moved from its seat, thereby connecting the source of vacuum with the power cylinder, *j*. The result of this is that the piston *k* in the cylinder is forced to the left by the atmospheric pressure against its outer side. A very interesting leverage action now occurs.

Let us first explain the action when the vacuum cylinder is entirely disconnected from the source of vacuum. The pull exerted on rod *a* by the pressure of the driver's foot would then be transmitted from lever *b* to lever *d* by way of floating fulcrum *c*, and thence to rod *l*. Since rod *l* is in line with rod *a*, the motion of both rods will be the same and there will, therefore, be no change in the pull; that is, the pull on rod *a* produced by pressing on the

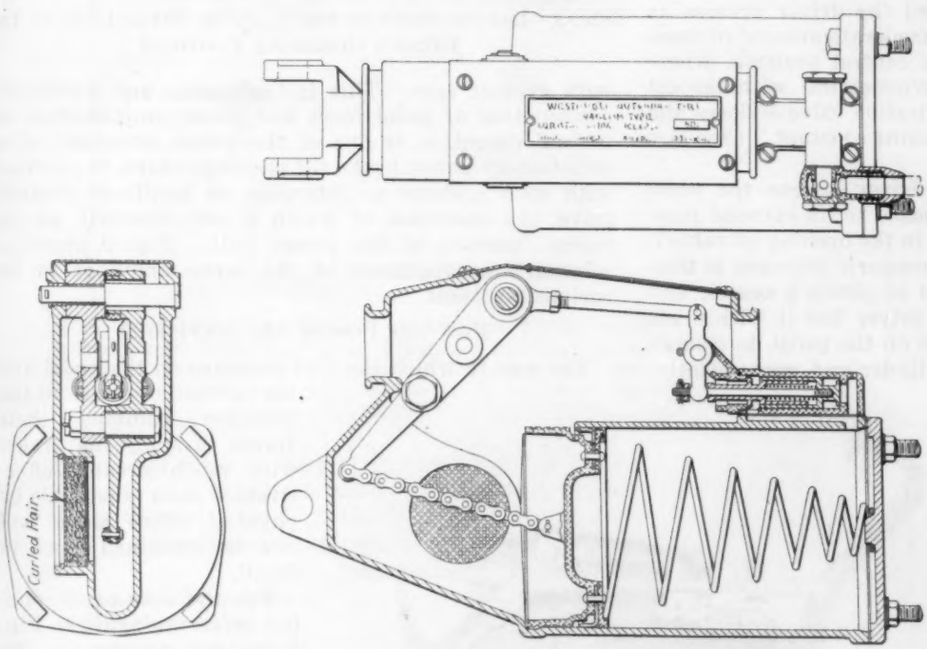


FIG. 4—SECTIONAL VIEW OF VACUUM BRAKE-UNIT

The Unit Is Comprised of an Operating Piston, a Simple Valve-Mechanism, and a Leverage System. The Double-Acting Operating-Valve Includes a Vacuum Connection and an Atmospheric Port to the Main Housing So That, Through the Valve Action, Air Can Be Exhausted from the Cylinder Proper or Ported to the Atmosphere. The Housing Is Fitted with a Breather and a Suitable Curled-Hair Strainer To Prevent the Admission of Road Dirt and Splashings

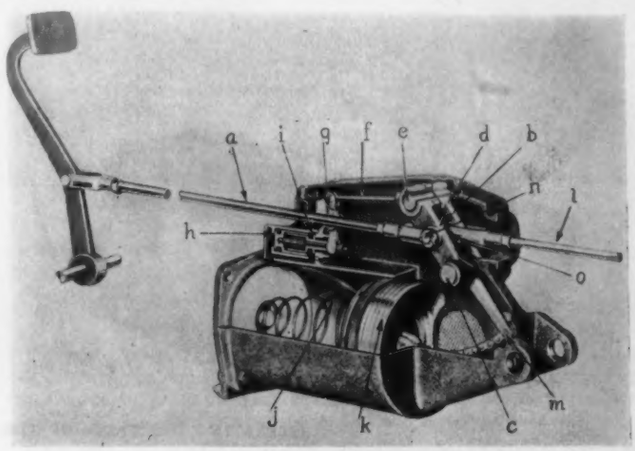


FIG. 5—SECTIONAL MODEL OF A VACUUM BRAKE-UNIT IN THE RELEASE POSITION

pedal will, in that case, be transmitted without modification to the brake-rod *l*. On the other hand, when the piston in the vacuum cylinder pulls on its chain, the lever *b* acts as a balance or equalizing lever, having vacuum pressure acting at *m* with pedal pressure at *n*. These forces combine at the fulcrum *c* and are multiplied through lever *d* to give an augmented pull on rod *l*. What this multiplication is will be explained in detail later.

When the driver first depresses the pedal, lever *b* will rock left-handedly around its floating fulcrum, *c*, whereby the valve-rod *f* is moved to the left and the application valve *h* is opened, as already explained. (See also Fig. 6.) However, as soon as the piston begins to pull on the lower end of lever *b*, the latter tends to return to its original position by rocking right-handedly about pedal-rod connection *n*. The exact action which then follows depends upon how hard the driver presses on the pedal. If he exerts only a moderate amount of pressure, lever *b* may return to a central position, where the eye at its upper end is symmetrical with respect to pin *e*. In that case the application valve *h* closes and the pull of piston *k* thereby remains constant. (See also Fig. 7.)

On the other hand, if the driver lessens the pedal pressure, the lever *b* will be rocked to its extreme position to the right, which results in the opening of valve *i*. (See also Fig. 8.) Air at atmospheric pressure is thus admitted to cylinder *j*, the pull of piston *k* ceases, and the brakes release. Thus the driver has it within his power, by pressing more or less on the pedal, to change the pounds of vacuum in the cylinder and, consequently, the pull applied to the brake-rod *l*.

It will, moreover, be evident that the force actually applied to the brake-drums is a combination of foot pedal-pressure and power generated in the brake unit. A greater retarding effect can thereby be developed with the customary pedal-pressure, or the same retarding effect with much less pedal pressure, thus giving adequate control

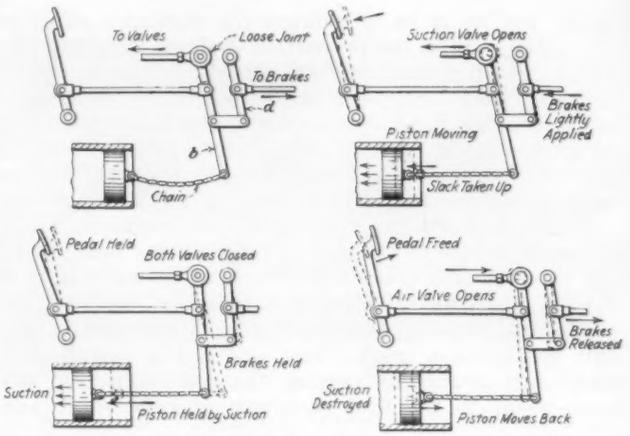


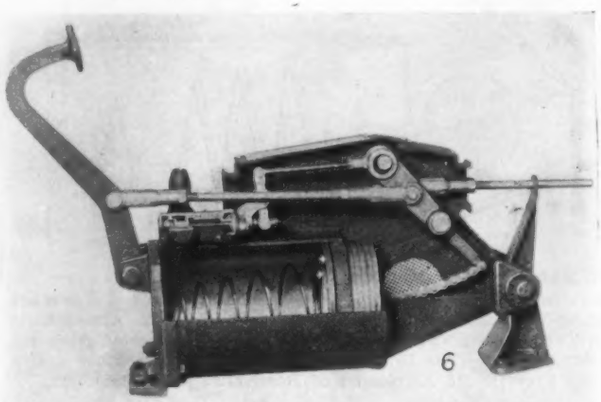
FIG. 9—ILLUSTRATIONS OF THE VACUUM BRAKE-UNIT IN ITS VARIOUS OPERATING POSITIONS

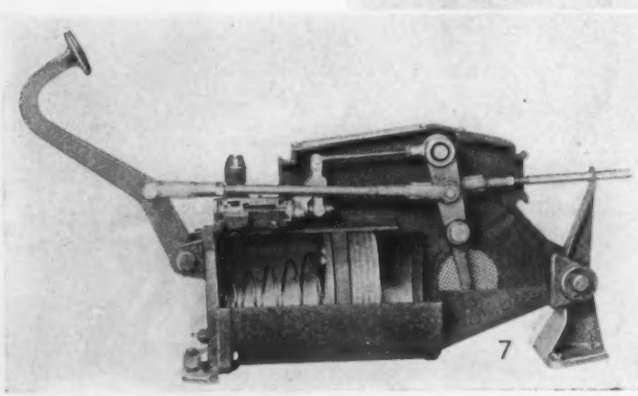
with greater ease. This instantaneous and automatic combination of pedal force and power amplification in normal operation is one of the prime essentials of a satisfactory power brake for passenger-cars, in contrast with such systems as interpose an auxiliary control-valve, the operation of which is not definitely an integral function of the power unit. Fig. 9 shows a schematic arrangement of the brake amplifier in its various positions.

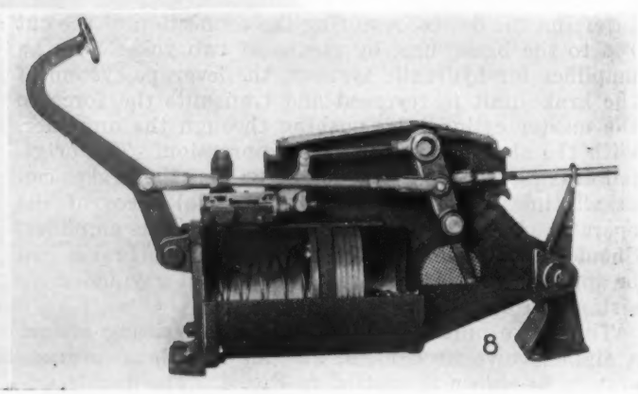
HOW THE FORCES ARE AMPLIFIED

The way in which the foot pressure on the pedal and the vacuum pressure in the amplifier combine their forces to apply the brakes with much greater effectiveness than is possible by physical effort alone will now be explained more in detail.

For the sake of simplicity, referring again to Fig. 5, we will assume for the time being that the upper arm *nc* of lever *b* is one-half the length of arm *mc*. Then, to balance the pull of







OPERATING POSITIONS OF THE VACUUM BRAKE-UNIT

Fig. 6—Application Valve Opened by Initial Pedal-Movement

Fig. 7—Valves in the Lap Position and Brakes Held Applied

Fig. 8—Release Valve Opened by Relaxed Pedal-Pressure

the vacuum piston, the driver would need to exert twice that pull on rod *a*. The force on fulcrum *c* would be the sum of the pulls on rod *a* and on the piston chain, which is equivalent to one and one-half times the pedal-rod pull. This pull is in turn multiplied through lever *d*, which has a 2-to-1 ratio. Hence, for a given pull, *F*, on pedal-rod *a*, a pull 3*F* is exerted on brake-rod *l*, and this ratio is maintained throughout the range of pedal pressures up to the maximum capacity of the vacuum brake-unit.

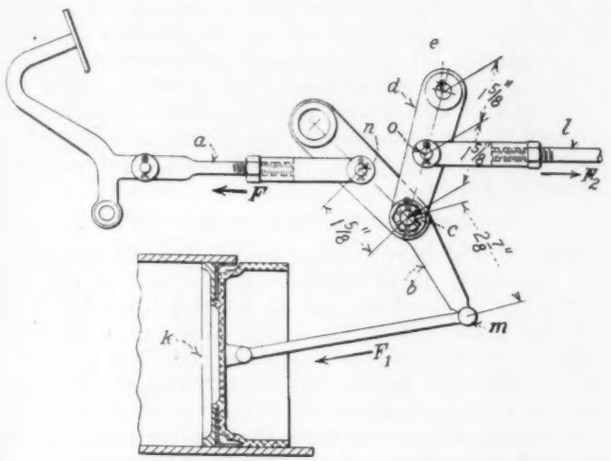


FIG. 10—PROPORTIONS OF THE VACUUM BRAKE-UNIT LINKAGE
The Actual Ratio of the Pull on the Brake-Rod *l* to That on the Pedal-Rod *a* When the Unit Is Operative Is Derived from This Diagram. The Calculations Apply to One of the Standard Passenger-Car Units

The actual ratio of the pull on brake-rod *l* to that on the pedal-rod *a* when the vacuum brake-unit is operative is derived from Fig. 10. The calculations apply to one of the standard passenger-car units.

Let

F = pull on pedal-rod *a*
F_1 = pull of piston *k*
F_2 = pull on brake-rod *l*

The problem is to determine F in terms of F_2, and we have

$$F_2 = (F+F_1) \text{ times the ratio of lever } d$$
$$= 2\ (F+F_1) = 2F+2F_1 \qquad (1)$$

$$F_1 = F\left(\frac{\text{lever arm } nc}{\text{lever arm } mc}\right) = F\ (1.625/2.875) \qquad (2)$$

Substituting the value of F_1 given by equation (2) in equation (1), we have

$$F_2 = 2F+2\ (0.565\,F) = 2F+1.13\,F = 3.13\,F \qquad (3)$$

That is, for every pound of pull exerted on the pedal-rod *a* by physical effort of the driver, there will be 3.13 lb. of pull developed on the brake-rod, as a result of the combination of muscular and mechanical forces.

The unit referred to in Fig. 10 has a piston 4½ in. in diameter. Other models of 5-in. and 6-in. diameters have substantially the same leverage ratios and produce a corresponding amplification. It is readily apparent, also, that any desired factor of amplification, or force multiplication, can be produced.

DIAGRAMS SHOWING FORCES DEVELOPED

Fig. 11 is a diagram showing the force developed on the brake-rod with the ordinary rigging. Assuming a pedal leverage of 4 to 1 and a pedal pressure of 97 lb., a pull of 388 lb. is developed on the brake-rod.

Fig. 12 shows that the same force is developed through the vacuum brake-linkage if an application is made mechanically without the aid of the amplifier. Fig. 13 shows that, with assistance from the vacuum amplifier, a much smaller pedal-pressure is required to produce the same force on the brake-rod. This 388-lb. pull on the brake-rod is produced by 194 lb. on the floating fulcrum *c* of lever *b* acting through the 2-to-1-ratio lever *d* as shown in Fig. 5. The components of this force of 194 lb. on equalizing lever *b* are a pull of 70 lb. from the amplifier piston and 124 lb. pedal-rod pull, which is, in turn, produced by a pedal pressure of 31

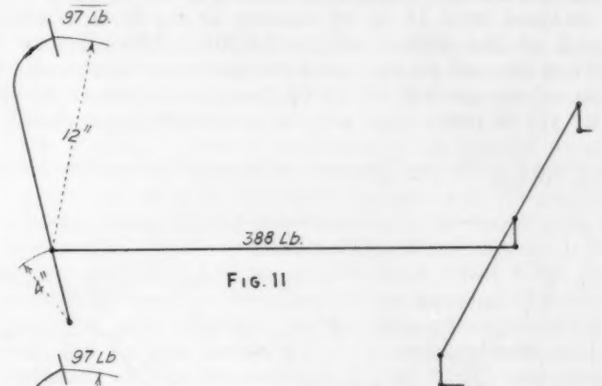


FIG. 11

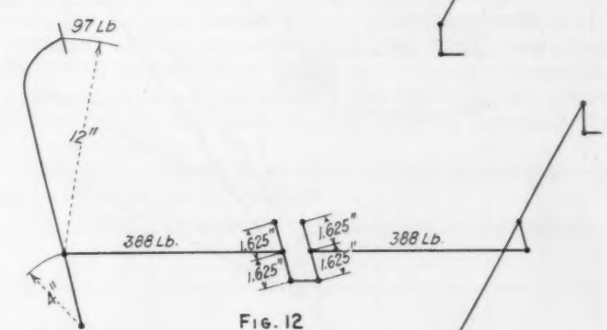


FIG. 12

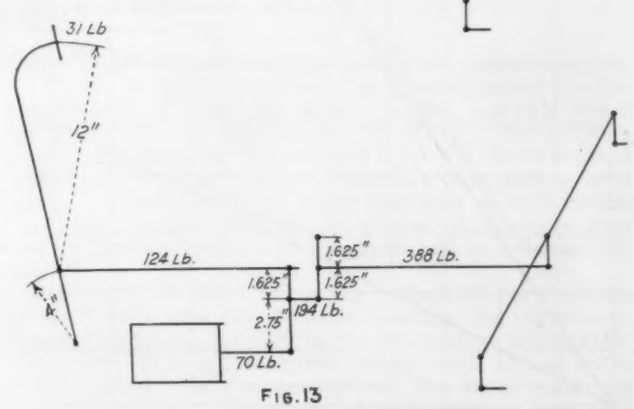


FIG. 13

VARIOUS DIAGRAMS OF BRAKE-UNITS

Fig. 11—Brake Application with Standard Brake-Rigging. Assuming a Pedal Leverage of 4 to 1 and a Pedal Pressure of 97 Lb., a Pull of 388 Lb. Is Developed on the Brake-Rod

Fig. 12—Brake Application Through Vacuum Brake-Linkage. The Diagram Shows That the Same Force Is Developed Through the Vacuum Brake-Linkage if an Application Is Made Mechanically without the Aid of the Amplifier

Fig. 13—The Diagram Shows the Reduced Pedal-Pressure Required To Obtain Brake Application with the Vacuum Brake-Amplifier

lb., as contrasted with 97 lb. when the brakes are operated by physical effort alone. If a greater braking force is now desired, a higher pedal-pressure will result in a correspondingly higher vacuum and a greater combined pull on the brake-rod. But, once the maximum capacity of the amplifier has been reached, any additional force will be obtained by mechanical means alone without further assistance from the amplifier. It should be emphasized, however, that in such cases the full effect of the amplifier is retained.

Capacity of the Various Units

With a 4½-in. diameter piston having an area of 15.9 sq. in., and assuming a pressure of 7.50 lb. per sq. in., obtained with 15 in. of vacuum at sea level, the total pull of the piston will be $15.904 \times 7.50 = 119.28$ lb. Then the pull on the pedal-rod necessary to equalize 15 in. of vacuum will be 119.28 times lever arm *mc* divided by 119.28 times lever arm *nc*, or 119.28 times $(2.875 \div 1.625) = 210$ lb. Since this unit has a leverage ratio of 3.13, the pull on brake-rod *l* will be $210 \times 3.13 = 660$ lb. The unit has a maximum stroke of 1¾ in.

With a 5-in. diameter piston having an area of 19.635 sq. in. the total pull of the piston will be $19.635 \times 7.50 = 147.26$ lb. To equalize the pull of the vacuum piston the pedal pull must be $147.26 (2.75 \div 1.625) = 248$ lb. This unit has a leverage ratio of 3.18. Therefore, the total pull on the brake-rod will be $248 \times 3.18 = 790$ lb. The unit has a maximum stroke of 1 11/16 in.

With a 6-in. diameter piston having an area of 28.2744 sq. in. the total force on the piston is $28.2744 \times 7.5 = 212.058$ lb. The pedal-rod pull necessary to balance this is $212.058 (3.5 \div 2.125) = 349$ lb. The lever ratio in this larger unit is 3.43. Hence, the force developed on the brake-rod at the normal capacity of the unit is $349 \times 3.43 = 1197$ lb. The unit has a maximum stroke of 2¼ in.

Capacity and Pull of the Units

Fig. 14 is a chart showing graphically the capacity of the foregoing three brake-units, as well as the pull which can be developed on the brake-rod with or without the assistance of the brake amplifier. The horizontal scale on this chart indicates pedal-rod pull ahead of the unit, and the vertical scale indicates the brake-rod pull after amplification through the brake unit. The lower diagonal line indicates the relative forces on the two rods when the amplifier is inoperative; that is, for every pound of pull on the pedal-rod, 1 lb. of pull is developed on the brake-rod. The steep diagonal line indicates that, for every pound of pull on the pedal-rod, a pull of 3 lb. is developed on the brake-rod when the vacuum brake-amplifier assists the driver's effort.

It will be noted that the capacity of a 4½-in. unit is reached at a total brake-rod force of 630 lb.; that of the 5-in. unit at 750 lb.; and that of the 6-in. unit at 1050 lb. These are slightly different from the figures previously mentioned because, in the chart shown in Fig. 14, an amplification factor of 3 has been used for all units for simplicity.

Branching off from the "capacity curve" in Fig. 14 are three other lines that parallel the lower line. They indicate that, after the maximum capacity of the brake units has been reached, additional braking effect can be realized by still further increasing the pedal pressure. Then, however, the brake-rod pull goes up in direct ratio; that is, without assistance from the vacuum brake-amplifier.

The 4½ and the 5-in. units are designed primarily for passenger-cars. The 6-in. unit has sufficient capacity for use on the smaller motorcoaches and on small and medium-capacity trucks.

[2] M.S.A.E.—General manager and director, Charles Street Garage Co., Boston.

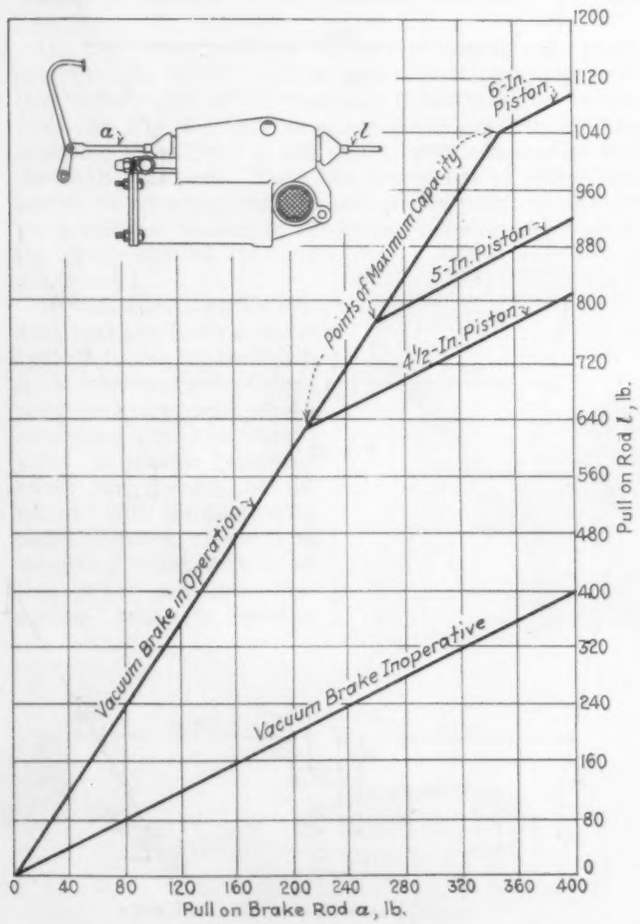


FIG. 14—CAPACITY LIMITATIONS OF VARIOUS VACUUM BRAKE-UNITS

The Chart Is Based on a 15-In. Vacuum Which Gives a Pressure of 7.5 Lb. per Sq. In. at Sea Level. The Ratio with the Vacuum Brake-Unit in Operation is 3 to 1; When It Is Inoperative the Ratio is 1 to 1. The Horizontal Scale Indicates the Pull on the Pedal-Rod *a* Ahead of the Vacuum Brake-Unit; the Vertical Scale Indicates the Pull on the Brake-Rod *l* After Amplification Through the Vacuum Brake-Unit, as Illustrated in the Upper Portion of the Chart

THE DISCUSSION

GLENN S. WHITHAM[2]:—Will Mr. Hukill explain why he said that it requires twice the effort to brake a car with four-wheel brakes as one with two-wheel brakes? Did he not mean the opposite?

H. D. HUKILL:—I meant that with four-wheel brakes approximately twice the brake-pedal force is required to lock the wheels as would be necessary with two-wheel brakes only. At the same time these will stop the car in approximately half the distance required to stop it with two-wheel brakes. The important point is that, assuming that the lever ratios and general foundation of the brake design remain undisturbed, it is necessary

to exert a pedal effort twice that formerly required if we are to take full advantage of four-wheel brakes.

FRANK E. H. JOHNSON[3]:—My understanding is that this device is connected by a pipe to the intake manifold of the engine. Mr. Hukill mentions a pressure of 7.5 lb. per sq. in., which corresponds to a 15-in. vacuum. What is ordinarily expected of an engine of 3½-in. bore? What is the pressure you have to work on? Can you count on that 15-in. vacuum?

MR. HUKILL:—A number of tests made on engines in fairly good condition averaged remarkably well. With an engine running at normal idling-speed, one can expect about 20 in. of vacuum in the manifold, which corresponds roughly to a pressure of 10 lb. per sq. in. If the engine is "raced" and the throttle is then closed quickly, the manifold vacuum will often increase to 25 or 26 in. during the period the engine, at a high number of revolutions per minute, is pulling against the closed throttle. At the same time, when the throttle is wide open and the engine is pulling hard at a low number of revolutions per minute, as is the case when climbing a steep grade in high gear, the vacuum will drop down to 2½ or 3 in. The increase in vacuum to the normal of 15 to 20 in. is, however, instantaneous when the throttle is closed or the foot is lifted from the accelerator.

EFFECT OF AIR ADMISSION ON CARBURETION

MR. JOHNSON:—What is the effect on the carburetion due to the amount of air that is admitted to the intake manifold at the time of brake application?

MR. HUKILL:—There is no noticeable effect with normal carbureter adjustment. The reason is that the displacement of a vacuum brake-unit is so small in comparison with the displacement of the engine. Consider an engine with a displacement of 250 cu. in. turning over at an idling speed of 200 r.p.m.—a total displacement of 50,000 cu. in. per min.—while the displacement of the vacuum brake-unit is approximately 100 cu. in. per application. Hence, it can be appreciated that there is relatively no effect upon carburetion. If the carbureter adjustment at idling speed is for a very rich mixture, a slight speeding-up of the engine for just an instant will be noticed as the brake is applied. We have found no cases in which the adjustment could be so lean that brake operation would have any detrimental effect.

O. A. LAWTON[4]:—I understand that the engine must be in operation; but if the car is at a standstill you cannot make any application of the vacuum brake-unit with the engine stopped, can you?

MR. HUKILL:—Power amplification is present at all times when the engine is running, and also with the ignition cut off when the car is in gear and the engine is being driven by the rear wheels, as is possible on a down grade. If the engine is stopped and the car is in neutral gear, there is no amplification effect from the vacuum brake-unit. But the existing mechanical brake-system is fully effective, without any added resistance from the vacuum brake-unit. In actual service-units, should no vacuum be available during brake operation, the piston lever swings freely without any movement of the piston, the chain between the lever and the piston collapsing into the space in the housing provided for this condition.

QUESTION:—How large a vacuum supply-pipe is needed to operate the brake?

MR. HUKILL:—Tubing of ½-in. outside diameter.

[3] M.S.A.E.—General service manager, Noyes Buick Co., Boston.

[4] A.S.A.E.—President and manager, Franklin Motor Car Co., Boston.

The Airship R-100

IT is proposed to utilize the British dirigible R-100 as a demonstration vessel and to operate her on a New York City-Montreal-London route, beginning next fall. On the lower floor are the crew's quarters, consisting of a mess deck and cabins. Leading from this to the upper floors is a double staircase, similar to that in a steamship, and on the lower passenger floor are two promenade decks, 14 ft. wide, made to permit dancing; a restaurant to seat 50 persons at one time, and cabin accommodation for that number. These cabins are of two or four berths, comparable with those on an Atlantic liner. Above this floor is yet another, on which further cabins are provided for 50 more persons; a smoking lounge, and two balconies.

As far back as 1919 the British airship R-34 crossed to America, and then made a successful return flight; and in 1925 the airship Los Angeles crossed the Atlantic.

Carrying the full load of passengers and 10 tons of mail or freight, the R-100 will have a radius of action of 4000 miles at a speed of 75 m.p.h. The R-100, however, was not built for the transatlantic service, but for the London-Egypt-India route; and even this vessel is not sufficiently powerful to undertake a service across the Atlantic on a regular schedule, carrying a full load of passengers in all weathers and in both directions.

The Airship Guarantee Co., which has constructed the R-100, has already worked out the general design for the transatlantic ship for the regular service, and this vessel will be as great an advance over the R-100 as the R-100 is over previous vessels. The cruising speed has been increased to 95 m.p.h. and the endurance increased from 4000 to 6000 miles. At the same time, more luxurious accommodation has been provided for passengers and the number that can be accommodated increased from 100 to between 160 and 170.

Airship development had a big setback in the disasters of the R-38 in 1921, the Roma in America, the Dixmude in the Mediterranean, followed by the Shenandoah catastrophe. The public felt that these great vessels would always suffer from inherent structural weaknesses. But engineers do not share this opinion. The causes of these disasters have been analyzed and obviated in the new designs.

The R-100 is five times as strong as any airship which has hitherto been built. Her cruising speed, furthermore, is approximately equal to the maximum speed of any vessel previously built; and it is thought that as a result of these two major improvements the R-100 should be able to encounter successfully even abnormal storms.—C. D. Burney, in *New York Times*.

Generation of Current for Automotive Apparatus

By B. M. LEECE[1]

CLEVELAND SECTION PAPER — *Illustrated with* CHARTS, DIAGRAMS AND PHOTOGRAPHS

EXACTING requirements for the generation of electric current for motorcoaches, airplanes and dirigibles, and how these needs are met by the manufacturers of generators, are described. Concurrently with the development of automotive vehicles, the installation of electrical equipment has grown and greater and greater demands have been made upon generators. Requirements change rapidly with development in the powerplant and in the general design of vehicles, so that manufacturers of electric generators are constantly faced with new conditions. Generators are now applied not only to private automobiles but to motor-trucks, motorcoaches, rail-cars, tractors, marine engines, stationary industrial engines, excavating shovels, oil-well drilling-machinery, airplanes and dirigibles. Each of these applications has its own peculiarities, and nearly all require continuous service over long periods. With the evolution of the motorcoach have come additional demands for lighting current and current for ignition, cooling and heating fans, heaters and pumps. All these must be supplied with dependable electric energy. A high degree of reliability in constant operation is also required of the generator on the latest airplanes and airships, for ignition, engine starting, radio communication, and lighting.

Electric generators are expected today to operate under widely varying specifications as to capacity, voltage, speed, load, and temperature. Under present commercial conditions, the generator capacity is often forced to the limit of material characteristics, and operation is continuous; therefore, the rating of such generators is a matter of concern to both the manufacturer and the user. Whereas the third-brush, or current-controlled generator gave fairly satisfactory service on private automobiles, charging the battery at an approximately constant rate in amperes, it was found undesirable when the equipment is to be used continuously, because the excess energy heats the electrolyte and plates after the battery is fully charged. In commercial applications it is desirable to have the generator start charging the battery at a low driving-speed and to be able to continue under full load up to the maximum speed of the vehicle. Hence the voltage-regulated type was developed, which supplies energy at an approximately uniform voltage and at a charge rate that tapers automatically in amperage. The characteristics of this type are discussed and compared with those that are inherent in the third-brush type.

It is not to be assumed, the author states in conclusion, that the present voltage-regulated systems are the ultimate to be achieved; experimental work is going on continuously to improve the performance, simplify the apparatus, and extend its applications. The electrical-equipment manufacturer, however, needs cooperation from the engine builder, who should realize that the generator equipment must occupy space proportional to the service demanded of it, and that proper driving speeds and means and better mounting arrangements should be provided.

Following the paper, discussion of the subject by motorcoach operators, on the one hand, and motorcoach builders and generator manufacturers, on the other hand, shows with clarity that many of the troubles that operators have with the electrical equipment are due to the installation of supplemental lights, fans, higher-power lamps, and other equipment which, together, require more current than the generator is designed to deliver. Other troubles are caused by the operation of motorcoaches in services requiring frequent stops with short intermediate runs, or by a combination urban service, calling for slow speed and numerous stops, and suburban or inter-urban service, calling for high speed with few stops. When the current source fails to meet the extra demands, the equipment maker is called upon to remedy the trouble.

IN the early days of the automotive industry the installation of any electrical equipment other than ignition equipment was discouraged, but it is now realized that an internal-combustion engine for automotive purposes requires a dependable source of electrical energy. Today, the electrical generating equipment is an inherent and indispensable component of the successful modern automotive powerplant.

Familiarity with the performance of electrical apparatus has bred confidence, and the tendency is to use more and more electrical energy for an ever-increasing number of kinds of service. Requirements change rapidly with development in the powerplant and general design of vehicles, so that the manufacturers of electrical generators for automotive uses are always faced with new sets of conditions. The variations in requirements seem unending and, as rapidly as conditions warrant, manufacturers of generators are developing types and capacities to meet the needs. For some time, passenger-car loads governed the trend of design. If sufficient energy were supplied to care for the operation of head, tail and dash lights, and to charge a comparatively small storage-battery sufficiently to crank the engine, the equipment was considered satisfactory. If such a system frequently charged the battery at a rate which boiled away the water from the battery, or if lamps were often burned out by a current of excessive voltage, poor battery-connections or broken leads, or if in the winter months the battery was not always sufficiently charged, these limitations were regarded as rather unimportant and among the disadvantages which

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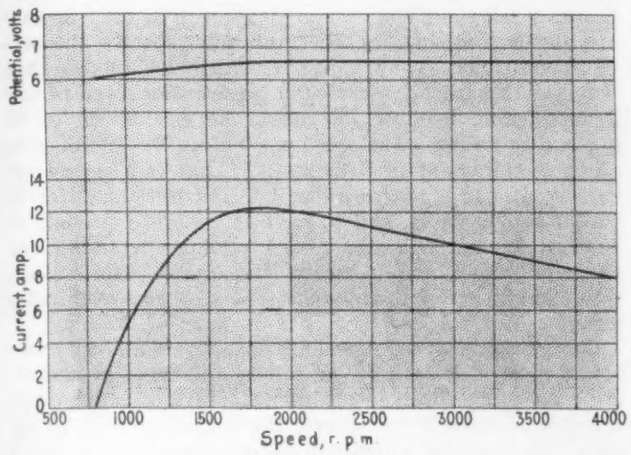

FIG. 1—CHARACTERISTIC CURVE OF A THIRD-BRUSH GENERATOR WITH A BATTERY LOAD

Above and Below Certain Driving-Speeds the Output of the Machine Is Greatly Reduced. It Is Customary To Adjust the Setting of the Third-Brush So That the Peak of the Output Curve Occurs at the Ordinary Driving-Speed

had to be assumed. Such an attitude on the part of automotive engineers and of the public has been replaced by the belief that electrical apparatus can be made which will meet every requirement, no matter how severe and exacting, and the tendency is to demand such equipment for widely differing applications, all of which the manufacturers of electrical apparatus are asked to accomplish within a low price-limit, especially in the field of passenger-cars.

As the commercial use of the internal-combustion engine broadened, another set of requirements arose. Today, electrical generators are applied to trucks, motorcoaches, rail-cars, tractors, marine engines, stationary engines, steam shovels, oil-well drilling-machinery, airplanes and dirigibles. Each of these applications has its own peculiarities. Nearly all require

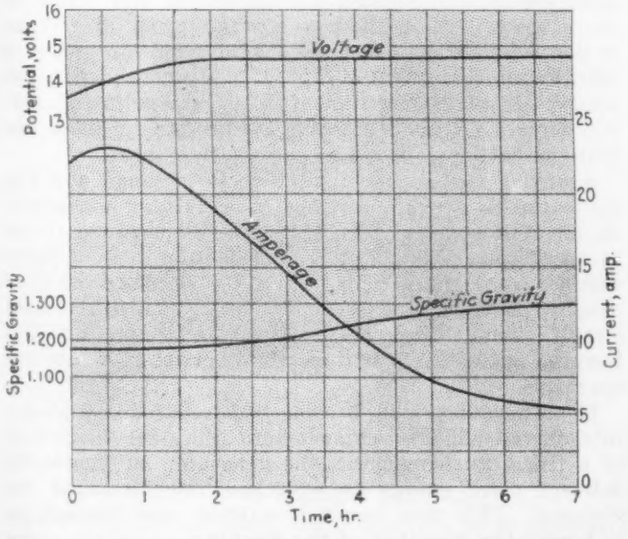

FIG. 2—BATTERY-CHARGING CURVE OF THE VOLTAGE-REGULATED GENERATOR

The Difference between Battery Voltage and Charging Voltage Decreases as the Battery Charges, Which Results in a Decreasing or Tapering Charging Rate in Amperes

continuous service over extended periods, whereas the operation of a passenger-car is generally intermittent.

DIVERSIFIED APPLICATIONS OF ELECTRICAL ENERGY

The modern motorcoach presents a good example of how electrical energy is being used. At first, a truck chassis was equipped with a motorbus body and a few dim lights were furnished. But luxurious motorcoaches for long-distance travel which are competing with other means of transportation are equipped with head, tail, sign, marker, door, body and signal lamps. In many instances the lights are of high candlepower. Ignition, cooling and heating fans, heaters, pumps and, in some cases, electrical refrigeration, must be supplied with dependable electrical energy. A comparison of such a load with that of a passenger-car generator is enlightening. Even on passenger-cars, we find lights of higher candlepower than formerly and more of them. Fuel-mixture heaters, cigar-lighters and other appliances are not uncommon.

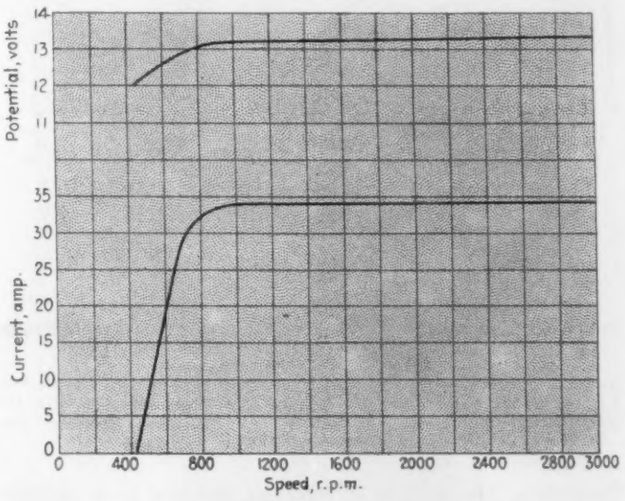

FIG. 3—TYPICAL SPEED-PERFORMANCE CURVE OF THE VOLTAGE-REGULATED GENERATOR OPERATING ON BATTERY LOAD

The airplane is being developed rapidly and requires a high degree of reliability in constant operation. Radio signalling on railroad trains presents another problem. Large dirigibles, such as are being built, require enormous amounts of electrical energy to be generated from a multiplicity of powerplants and transmitted for distances of several hundred feet. Recently, one company has been working on the design of generating equipment for a dirigible approximately 700 ft. long. The design calls for eight generators, running in parallel, to meet the voltage requirements of the storage-battery.

In commercial-car applications an entirely different set of conditions is encountered. In general, a commercial vehicle is operated every day. Uninterrupted service to the maximum degree is a requisite of profit. Such repairs and replacements as are made must be effected quickly while the vehicle is off duty.

Electrical generators today are expected to operate under widely varying specifications as to capacity, voltage, speed, loads, time and temperature. Loads are being increased, despite the fact that the designers of automotive powerplants seem to have overlooked the fact that a generator of large capacity must perforce

occupy a relatively large space. It would be impossible to mount automotive generators if the manufacturers were allowed to rate them as industrial generators are rated.

In the past, when loads were comparatively small and service was intermittent, the rating of an automotive generator was of secondary importance. So long as it operated in a fairly satisfactory way, that was all that seemed to be expected. But under present commercial conditions this is no longer true, for the generator is often forced to the limit of the characteristics of its materials of construction, and operation is continuous.

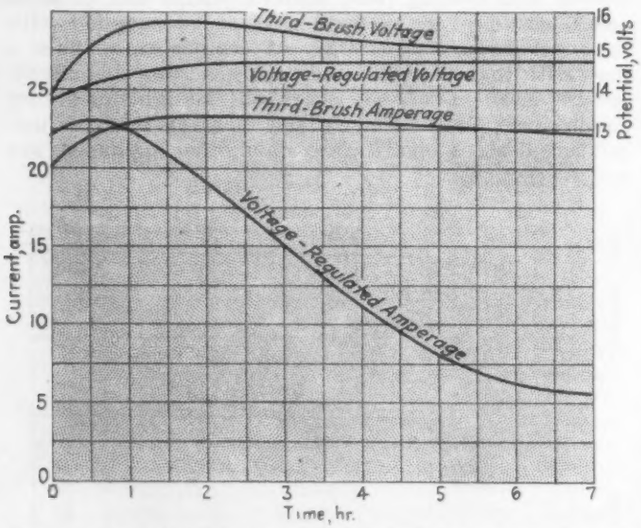

FIG. 4—VOLTAGE-REGULATED AND THIRD-BRUSH GENERATORS COMPARED

The Curve and the Voltage Characteristics of the Two Types Are Plotted to the Same Scale for Comparative Purposes. It Will Be Noted That There Is a Considerable Difference Between the Charging Rates as the Charge Proceeds

Therefore, the rating of such generators is a matter of concern to the manufacturer and to the user. Increased loads have affected the capacity and design of modern automotive generators. Formerly, a 10 to 15-amp. 6-volt generator was thought a sizable one for automotive uses. Now, demand has arisen for 1000 and 1500-watt generators to be driven at very low speeds. In general, modern automotive generators fall into the following classifications.

CLASSIFICATION OF AUTOMOTIVE GENERATORS

(1) As to voltage, generators are used commonly in connection with lead storage-batteries of 3, 6 and 15 cells. These correspond to the customary 6, 12 and 30-volt classifications. There is also some interest in 110-volt generators in automotive sizes

(2) As to current, generators are required with current capacities from 10 to 75 amp.

(3) As to wattage, the requirements run from 125 to 1500 watts, with no assurance that the latter figure is the maximum

(4) As to speed, generators have been requested which balance the battery voltage at as low a speed as 200 r.p.m., or at a vehicle speed of about 5 m.p.h. Airplanes require a balancing speed of around 2000 r.p.m., which gives a ratio between low and high speed of 10 to 1

Very few motorcoach operators like to have a manufacturer tell them that the vehicle must be used in only one service, or that the operator must specify the service conditions. They want the vehicle designed so that it is suitable for city service at an average speed of say 9 m.p.h. and also for interurban service at 50 to 60 m.p.h.; and they want the same output from the generating equipment in both cases. That is a severe requirement. It is not so difficult to get the generator to cut in at 200 r.p.m. and to have it generate current at 3500 r.p.m., but with the restricted space available for the equipment, commutation difficulties arise. Electrical engineers will appreciate what that speed ratio means.

Commercial-car requirements necessitate a large number of generator designs, capacities and types of mounting. As competition in the manufacture of commercial vehicles becomes more severe, the engineers seek to incorporate features which will differentiate their product from others. Frequently such novelties of construction effect the manufacturer of so indispensable a unit as the generator, forcing him to fit the unit to the conditions imposed by the design of the power unit and the vehicle and to the service intended. Too often, generator considerations are an afterthought.

TYPES OF GENERATOR AVAILABLE

The third-brush or current-controlled generator has been used on passenger-cars for a number of years. There have been and still are some limitations to its performance but, in general, it has been found to be a fairly satisfactory generator for this service, all things considered. When adjusted for rated output at required speed, the third-brush generator will charge a battery at an approximately constant rate in amperes no matter what may be the state of charge of the battery. In fact, the third-brush machines give slightly higher outputs when the battery is up. This constant rate of charge has been rather undesirable when the equipment is to be used continuously, for a prolonged high charging-rate will charge the battery fully and the excess energy which the generator furnishes can be absorbed only in heating the electrolyte and plates of the battery, causing the water to be driven off. There is danger that the batteries may become dry when a third-brush generator is used continuously for extended periods unless the third brush is adjusted normally for a low rate. If this is done, the chances are that the battery will not be sufficiently charged.

Should a battery terminal become loosened and the generator be operated without the battery connected, its terminal voltage is uncontrolled and is proportional to speed, and this often results in a rise in voltage which burns out the lamps connected or blows the fuse usually provided in the field circuit. With the field circuit open, the generator is protected against the burning out of the armature winding but it is also inoperative.

If battery terminals become badly corroded, thereby introducing added resistance into the external circuit of a third-brush machine, the generator automatically delivers more energy to overcome the increased resistance. This may result in current high enough to endanger the windings of the machine.

A characteristic curve of a third-brush generator with a battery load is shown in Fig. 1. It will be noted that there is a decided peak in the curve. Above and below certain driving-speeds the output of the machine

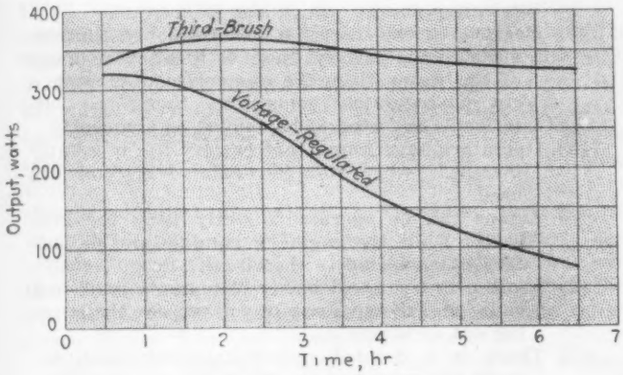

FIG. 5—COMPARISON OF WATTAGE CURVES

The Wattage Output of the Voltage-Regulated and the Third-Brush Generators, When Operated on Batteries of the Same Size, Are Compared

is greatly reduced. It is customary to adjust the setting of the third brush on the generator so that the peak of the output curve occurs at what is believed to be the average driving-speed. It will be appreciated immediately that an average driving-speed is more or less a phantom. Who can say just what the average speed of a number of vehicles is to be in service? A motor-coach may be in high-speed interurban-service one day with few stops, and in low-speed frequent-stop city-service the next day. A compromise is reached in the setting of the third brush, when one is used. It has to be altered frequently to meet special conditions in service.

On present commercial applications it is desirable to have the generator start charging the battery at low driving-speed and to be able to continue under full load up to the maximum speed of the car. The ratio between the maximum and the minimum speed may be as much as 10 to 1, but a 5-to-1 ratio is the usual requirement. The third-brush-generator characteristic performance does not meet this requirement. Neither can a third-brush generator carry the lighting load if the battery becomes inoperative, unless it is voltage regulated. For these and other reasons it is found that the conventional third-brush generator leaves much to be desired for commercial-vehicle application.

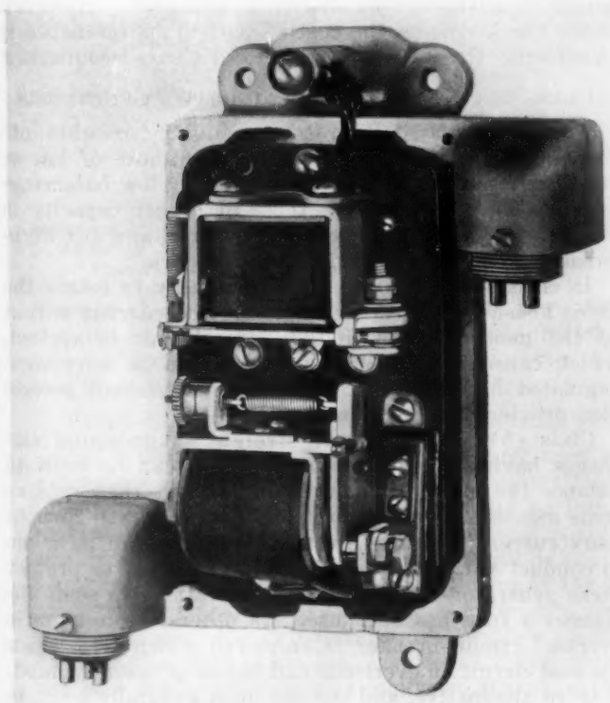

FIG. 6—TWO-ELEMENT REGULATOR

This Control Unit Is Used with Voltage-Regulated Generators Which Are Equipped With a Third Brush. The Upper Element Is a Conventional Circuit-Breaker or Cutout Relay, the Function of Which Is To Disconnect the Generator from the Battery When the Engine Is Not Operating or When It Is Idling at Very Low Speeds. The Lower Element Is the Voltage-Regulator Element

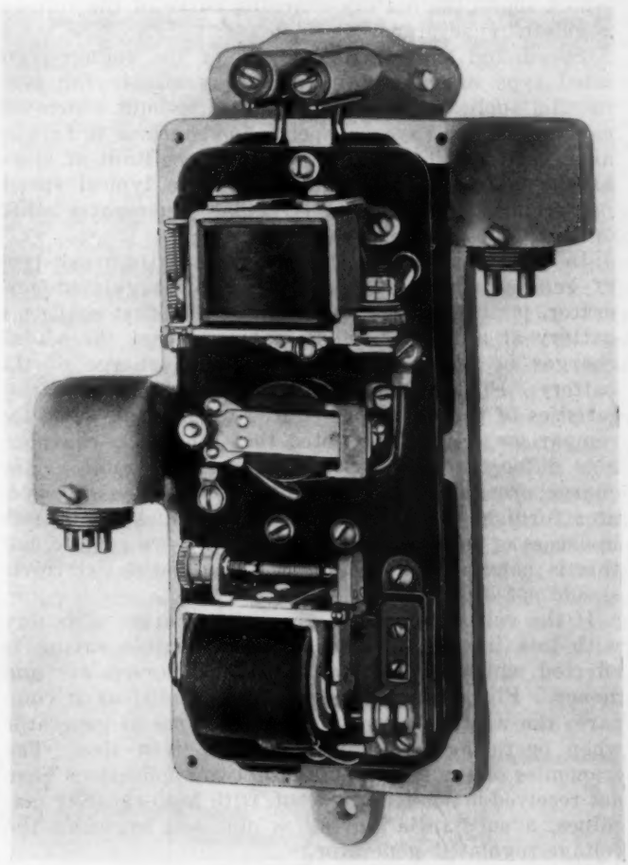

FIG. 7—THREE-ELEMENT REGULATOR

This Type of Control Unit Is Used with Shunt-Wound Generators for High Capacity at Low Speed, Such as Employ No Internal Current-Limiting Means. The Upper Element Is the Cutout Relay, the Central Unit the Current-Limiting Device, and the Lower Element the Voltage Regulator

VOLTAGE-REGULATED TYPE OF GENERATOR

The idea of voltage regulation of generators is not new, but its adaptation to automotive requirements involved considerable development. Whereas the third-brush generator is controlled to furnish a fairly constant current, the voltage-regulated generator is arranged to supply electrical energy at an approximately uniform voltage. In short, the voltage-regulated generator approaches the performance of a constant-po-

tential generator, the voltage being regulated within close limits. Strictly speaking, however, the voltage-regulated generator, as constructed at present by several companies, is a modified form of the constant-potential generator. But the result is that the voltage-regulated generator produces a charging rate in amperes which is automatically tapering. If the battery is in a discharged condition, the charging rate will be comparatively high. If the battery is fully charged, the charging rate will be low. As a discharged battery is charged, its voltage slowly rises. The difference between battery voltage and charging voltage decreases, which results in a decreasing or tapering charging rate in amperes. This characteristic is illustrated in Fig. 2, which shows the battery-charging curve of the voltage-regulated generator.

Speed and load characteristics of the voltage-regulated type of generator are more suitable for commercial application. Generators can be built which will carry full load at normal speeds and continue to furnish almost their full rated energy up to the limit of speed of the engine. Fig. 3 illustrates the typical speed-performance of the voltage-regulated generator when operating on a battery load.

In comparing the operation of the third-brush type of generator with that of the voltage-regulated generator, it must be remembered that the first charges a battery at a fairly uniform rate and that the second charges in proportion to the state of charge of the battery. Fig. 4 shows the current and voltage characteristics of the two types plotted to the same scale for comparison. It will be noted that there is a considerable difference between the two charging rates as the charge proceeds; that is, the third-brush type of genator furnishes to the battery energy which is at times in excess of its needs. It may charge more rapidly, but this is not an unalloyed virtue because the electrolyte should not be overheated.

If the voltage-regulated generator charges a battery with less input of energy, an appreciatble saving is effected which can be translated into horsepower and money. Fig. 5 illustrates this graphically, as it compares the wattage output of the two types of generator when operating on a battery of a given size. The economics of the operation of the two applications have not received much attention but, with high-capacity machines, a substantial saving is obtained by using the voltage-regulated generator.

The inadequacy of the couplings first employed called to the attention of some automotive engineers the importance of power inputs to large generators. Large-capacity generators require a proportionately large amount of power to drive them.

Advantages of the Voltage-Regulated Generator

Several years of successful application of voltage-regulated types of generator to a large number of different kinds of service has emphasized certain advantages resulting from their use, as follows:

(1) If a voltage-regulated generator is properly adjusted, connected batteries cannot be overcharged
(2) The battery is charged at a rate proportionate to its need of charge. If it is in a discharged condition, the charging is rapid at first, as it should be. If it is fully charged, the charging rate in amperes is very low; in effect it is a trickling charge, which also is desirable
(3) Because excess energy is not furnished continuously to the battery, there is less boiling away of the water from the electrolyte than with a current-regulated generator; therefore, batteries do not need to be refilled as frequently
(4) Operators have found that battery life is greatly increased when voltage-regulated systems are used
(5) Lamps can be operated directly from the generator while the engine is running and no battery is connected in the circuit
(6) Loose or corroded battery-terminals will not cause an excessive rise in voltage nor the burning out of lamps
(7) There is a decided economic consideration because the output of the generator is proportionate to the load required, which means that the power input to the generator is in accordance with its power output
(8) The generator is usually designed so that it can carry its rated load without assistance from the battery
(9) According to one large-scale operator of motor-coaches, the cost of operating batteries with voltage-regulated equipment is as low as 0.0015 cent per coach-mile

Voltage-regulated systems have been in use long enough to justify the conclusion that they are the most satisfactory type of apparatus now known for the various needs of commercial automotive applications, and the prediction is made that this type will find its way in the near future into the field of passenger-cars, for which it seems to have many advantages, offset by the single disadvantage of increased first cost. However, when the saving in the cost of battery maintenance is considered, the item of first cost is not so discouraging.

Classification of Voltage-Regulated Generators

Voltage-regulated generators are divided roughly into the following three main classes: (*a*) those of low or medium capacity in which an extremely low balancing-speed is not required, (*b*) those of higher capacity in which a low balancing-speed is desirable, and (*c*) high-capacity generators for high-speed service.

In classes (*a*) and (*c*) it is customary to retain the third brush as a means of limiting the current output of the generator. A voltage-control unit is applied, which causes the generator to function as a voltage-regulated machine with the inherent overload protection provided by the third brush.

Class (*b*) generators are straight shunt-wound machines having no third brush. These can be built to balance the battery at lower speeds; but they require some means of overload protection, as they will furnish more current than the armature winding can be made to conduct without overheating. It is usual to protect these generators by some external means. In some instances a fuse has been used; in others, an automatic overload circuit-breaker is employed which trips open the load circuit on overloads and has to be reset by hand. A third alternative, and the one most generally used, is to incorporate a current-limiting element in the control unit to limit automatically the current which the generator can deliver and which does not have to be reset by hand. Such current-limiting devices have been used on each of the three classes of generator.

Fig. 6 illustrates the two-element type of control unit used with voltage-regulated generators equipped with a

third brush. The upper element in the assembly is a conventional circuit-breaker or cutout relay, the function of which is to disconnect the generator from the battery when the engine is not operating or when it is idling at very low speed, thus preventing any chance that the battery may discharge back through the generator circuit. This element is no different in theory from those employed on passenger-cars but is more closely adjusted. On a voltage-regulated system there is no great peak of over-voltage, when the generator is speeded up on starting, to close the circuit-breaker even if it be sluggish, for the voltage is limited. Therefore, the cutout relay used is constructed to operate within closer limits than the conventional ones.

The lower element shown in Fig. 6 is the voltage-regulator element. This consists of a magnetic circuit, energizing coils, and a vibrating armature for opening and closing contacts, which responds in frequency to

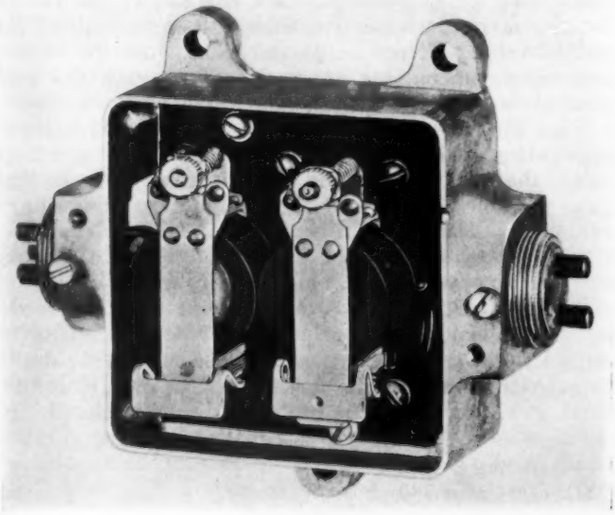

FIG. 8—SMALL TWO-ELEMENT REGULATOR

This Small Type Is Designed for Machines of Low Capacity; That Is, 10 or 15 Amp. at 6 or 12 Volts. The Voltage Regulator Is Shown at the Left and the Cutout Relay at the Right

changes of speed and variations of load in the external circuit. This armature cuts a regulating resistance into and out of the field circuit of the generator. The field circuit of the generator is not opened.

THREE-ELEMENT AND TWO-ELEMENT REGULATORS

Fig. 7 illustrates the type of control unit used with generators for low speed and of high capacity; that is, those shunt-wound generators that employ no internal current-limiting means. The upper element in the assembly is the cutout relay, the central unit is the current-limiting device, and the lower element is the voltage regulator. There is no essential difference in the construction of the cutout relay and voltage regulator as compared with those just mentioned. The current-limiting device consists of a magnetic circuit, a movable armature and contact points; it simply cuts resistance in and out of the field circuit, adding to the resistance across the voltage-regulator points, and is responsive to load. When an overload occurs, the element operates in conjunction with the voltage regulator to limit the amount of current the generator can supply, by modifying the field strength of the generator.

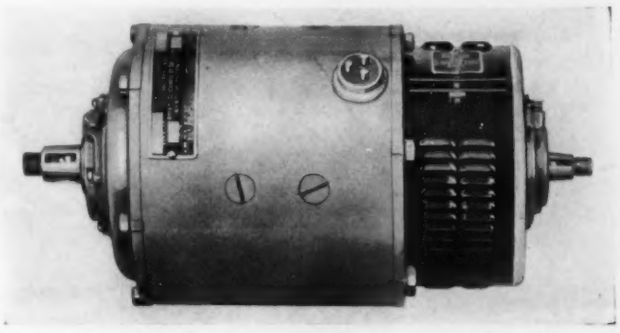

FIG. 9—GENERATOR SHOWING TERMINAL BLOCK

In Fig. 6, 7 and 8 It Will Be Noted that Each Control Unit Carries a Three-Pronged Terminal for Connecting to the Generator. A Similar Terminal Block Is Mounted on the Generator as Shown Herewith. Two of These Terminals Connect to the Generator Brushes, Positive and Negative. The Third Terminal Connects to One End of the Generator Field-Winding, the Other End of the Field Being Connected to the Brush Inside the Generator

For machines of low capacity, 10 or 15 amp. at 6 or 12 volts, a small type of control unit, as shown in Fig. 8, has been developed and widely used. The voltage regulator is shown as the left-hand element in the assembly; the cutout relay is shown at the right. There is no essential difference in the construction of these smaller units except in size. The size of the box shown is about 4 x 4 x 4 in.

It will be noted in the three illustrations of control units that each carries a three-pronged terminal for connecting to the generator. The generator end of this arrangement is shown in Fig. 9. Two of these terminals connect to the generator brushes, positive and negative. The third terminal connects to one end of the generator field-winding, the other end of the field being connected to the generator brush inside the generator. The three conductors connecting the control unit and the regulator can be inclosed in a protecting

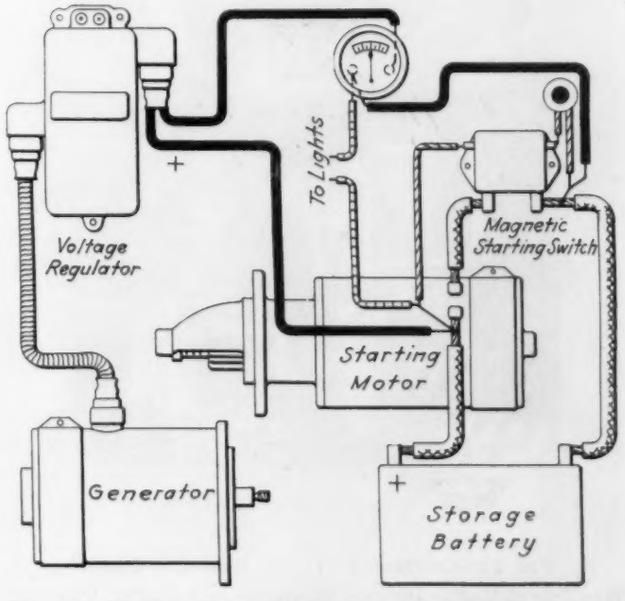

FIG. 10—WIRING DIAGRAM SHOWING VARIOUS METHODS OF CONNECTING THE CONTROL UNIT INTO THE CIRCUIT

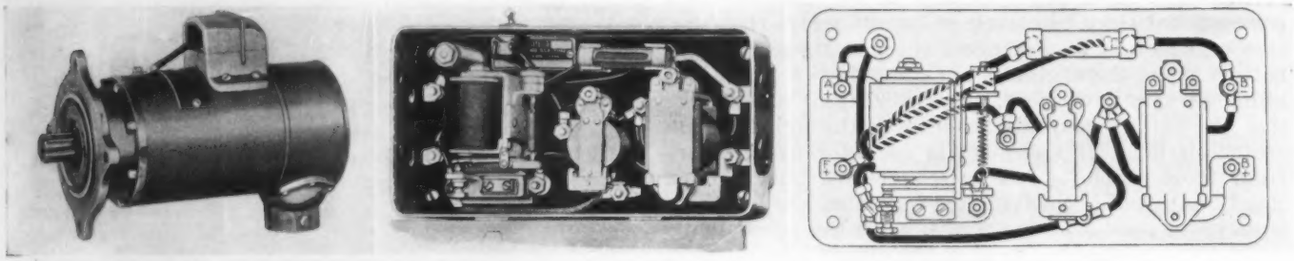

FIG. 12—TYPE G-1 GENERATOR, CONTROL BOX AND WIRING DIAGRAM

The 15-Amp. 12-Volt Generator Shown at the Left Is Designed To Mount on the Newest Types of Engine. In the Central View Is the Control Unit Supplied with This Generator. It Comprises the Voltage-Regulator Element Shown at the Left, the Load-Limiting Device Shown at the Center, and the Cutout Relay Shown at the Right. The Wiring Plan of the Control Unit Is Shown in the View at the Right

armor. The field terminal is smaller than the other two. This, coupled with the triangular arrangement of the metallic prongs, makes it impossible to attach the connecting cable-terminals improperly. This type of connection has been found to eliminate many troubles in installation and replacement and has met with favor among users.

METHODS OF CONNECTING THE CONTROL UNIT

Fig. 10 illustrates various combinations of the method of connecting the control unit into the circuit. It is obvious that no complication is introduced which would be troublesome. The connecting cable, carrying three wires from generator to regulator, obviates any possibility of error on that end. From the control unit either one or two load-terminals are provided, with the polarity marked on the outside of the box.

EQUIPMENT FOR RAIL-CAR SERVICE

Another variety of the equipment is for use with 15 lead cells, principally for application to gasoline-engined rail-cars. It has been found that, if no more than 15 cells are used, there is no need of a lamp regulator; consequently, the voltage rating of such apparatus is 30.0 to 37.5 volts, figuring 2.0 volts per cell if discharged and 2.5 volts per cell if charged. The 37.5-volt potential does not burn out the lamps available for this service. In rail-car operation, another requirement is that the cutout relay must function so that, if the car be bumped severely while switching, the armature of the cutout relay will not be jarred shut, close the circuit and allow the battery to discharge through the generator.

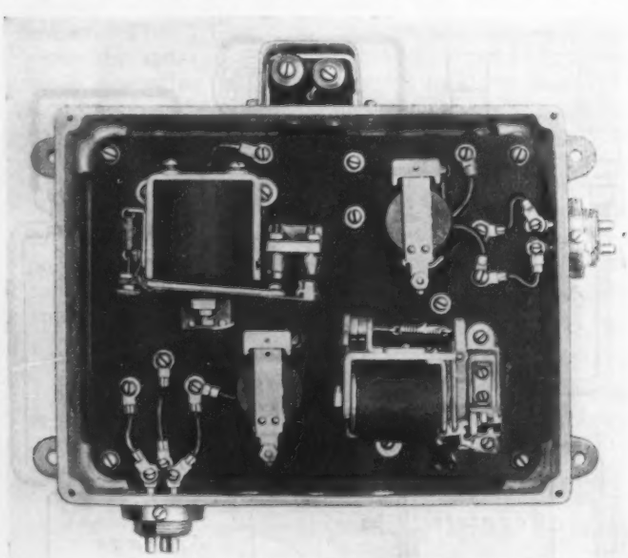

FIG. 11—CONTROL UNIT FOR RAIL-CAR USAGE

This Type of Unit Is Designed for Service on a Battery Consisting of 15 Lead Cells. The Upper Left-Hand Element Is the Current-Limiting Device and the Lower Right-Hand Element Is the Voltage Regulator

Fig. 11 illustrates the control unit for 15-lead-cell application. The upper left-hand element is the cutout relay, the upper right-hand element is the current limiter, and the lower right-hand element is the voltage regulator. These are, in general, of the same construction as elements previously mentioned, except that they are built to operate on the higher voltage and the cutout relay is provided with a double contact. The lower left-hand element is a trip relay which functions in conjunction with the cutout relay so that, should the cutout-relay armature be jarred shut, or even closed by hand, it will not allow the contacts to remain closed. In other words, the trip relay functions to prevent the series winding of the cutout relay ever being able to overpower the shunt winding.

APPLICATION OF VOLTAGE REGULATION TO AIRCRAFT

Voltage regulation has been found to be essential to the satisfactory operation of generators for aircraft application. In this service the engine runs at a fairly constant high speed and, especially in cross-country flying, for long periods. In addition, it is highly desirable to have a source of approximately constant-potential electrical energy for the operation of radio and other devices.

Technicians of the Army Air Service were among the first to appreciate the advantages of voltage regulation as applied to their problems, and since the war a continuous and uninterrupted program of development has been carried on which has resulted in a line of generators and control units for aircraft. When slightly modified, these serve admirably on commercial airplanes. The Air Corps requirements, which include radio operation, are much more rigid than those necessary for commercial aviation.

Fig. 12 illustrates, at the left, a 15-amp. 12-volt generator such as is used by both the Army and the Navy Air Services and that also has been applied to a number of commercial airplanes. The generator is designed to mount on the newer types of engine and is provided with an internal spring-coupling or drive to relieve the armature shaft of sudden strains imposed by rapid acceleration.

The control unit supplied with this generator is

shown in the central view in Fig. 12. The assembly comprises the voltage-regulator element, shown at the left, the load-limiting device, at the center, and the cutout relay, at the right. These elements are similar in construction to those previously described except that more care is exercised in balancing the winding for heat changes and generally adjusting the operation to be within the very close limits imposed by radio requirements. The wiring plan of this control unit is shown at the right in Fig. 12.

A special controlling resistance in series with the shunt winding of the voltage-regulator element is shown at the right in the wiring plan in Fig. 12. As the copper wire of the winding heats, its resistance increases; but, as the resistance unit heats, its resistance decreases and this balances or compensates the increase in resistance of the winding automatically and prevents voltage variations due to heat. This device makes it possible to cause the generator to charge the battery for a few minutes at a very high rate on starting, then, automatically, the voltage will be lowered so that a normal charging-rate follows. Hence, if the starting motor on an airplane has been used to start the engine, exhausting or partly exhausting the very small battery carried, the battery can be charged very rapidly for the first few minutes in the air, thus providing some charge in case of an immediate forced landing.

Two-Element Control for Aircraft Generators

A two-element control-unit is also available for use with the 25 and the 50-amp. aircraft generators. This is very similar to the two-element control-units described in connection with commercial-vehicle applications, except for the fact that it is housed in a lighter container.

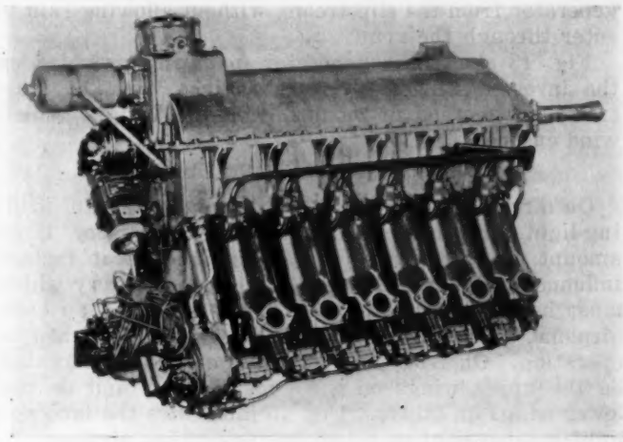

Fig. 13—Method of Mounting a Generator on the Inverted Liberty Engine

Table 1 gives the types and ratings of generators developed for the Army Air Service. It indicates the variety of conditions for which the manufacturer must provide in modern production of generators for aviation purposes. These are Army types. Slight variations are required for the Navy, and a duplicate number of types are provided for commercial airplanes. It is interesting to note the output ratings of these generators considered on a basis of weight.

In aircraft application, the generators are provided with a vent tube fitting into the commutator band. This tube extends up through the cowling of the ship and terminates in a short right-angled pipe which is turned backward. This causes a suction of air through the

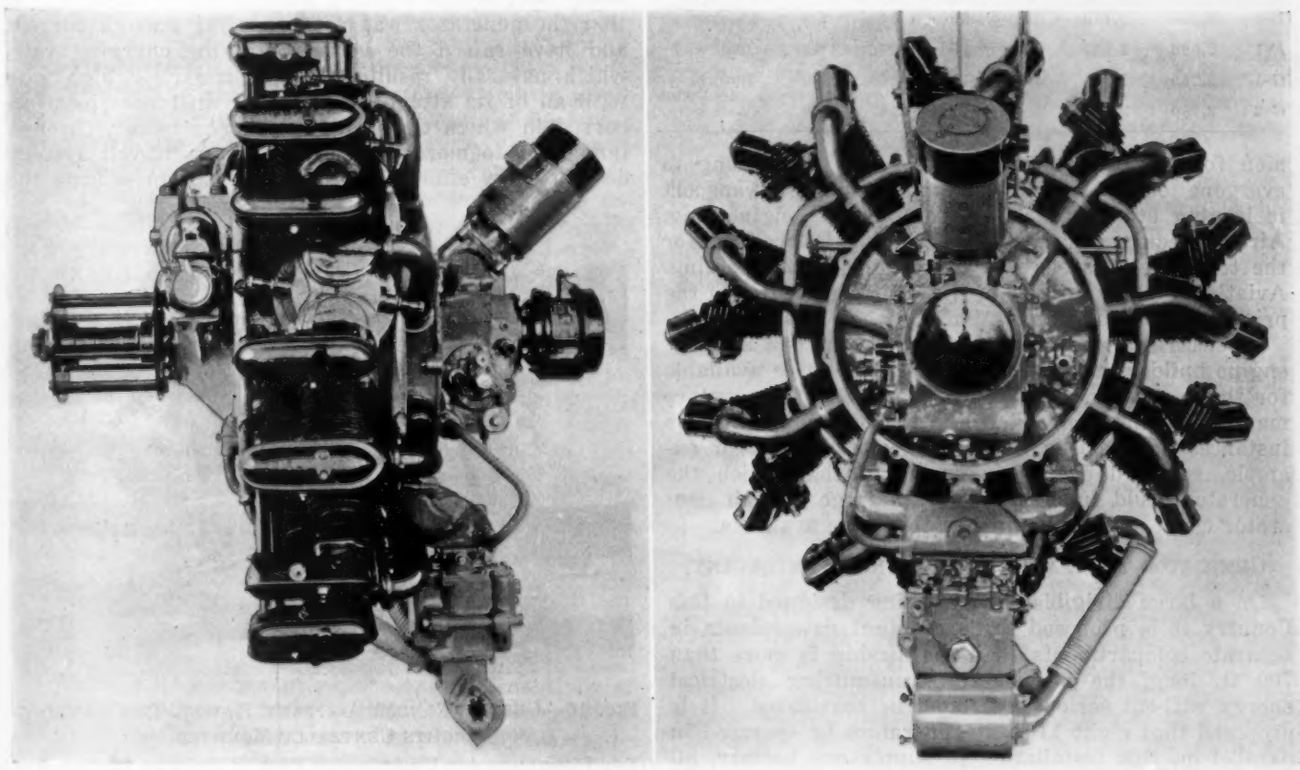

Fig. 14—Method of Generator Mounting Used on the Wright Whirlwind Engine

generator from the slipstream, without allowing rain to enter through the vent.

Fig. 13 shows the generator mounting provided on the inverted Liberty aircraft engine. Fig. 14 illustrates the method of mounting on the Wright Whirlwind engine.

Provision for Lighting Current

On aircraft equipped for night flying, powerful landing-lights are necessary. These draw a very large amount of current and are one of the great factors influencing the size of the generator and battery which must be used. Two of these lamps are used on each airplane, each drawing approximately 45 amp. when in operation. On B1-type airplanes the lamps are located on the upper wings on some installations and on the lower wings on others. Fig. 15 illustrates the landing-light arrangement on a Loening amphibian airplane.

Fig. 16 is a view of the new Curtiss Condor airplane, showing the two landing-lights centrally mounted. Two generators operating in parallel are used, one on each of the two engines. This is one of the few installations of its kind in existence.

Aircraft materiel has been emphasized in this discussion for several reasons. First, it is interesting to everyone today. In electrical application, air transport is leading other branches of automotive engineering. Aircraft equipment is a good proving laboratory, for the tests are rigorous and the requirements exacting. Aviation applications are proving the correctness of the principle of voltage regulation.

TABLE 1—AIRCRAFT GENERATORS AVAILABLE

Type	Generator Speed, R.P.M.		Rated Potential, Volts	Rated Line-Current, Amp.	Maximum Weight, Generator Only, Lb.	Outside Diameter, In.	Direction of Rotation at Drive End
	Minimum to Carry Rated Load	Normal					
B-1	2,000	2,250	15	25	28	5.0	Clockwise
C-1	2,000	2,250	15	50	44	6.0	Clockwise
D-1	2,250	2,750	15	25	20	4.5	Counter-clockwise
E-3	2,250	2,750	15	50	35	5.5	Counter-clockwise
E-4	2,250	2,750	15	50	35	5.5	Clockwise
F-1	2,000	2,250	15	15	24	4.5	Clockwise
G-1	2,250	2,750	15	15	16	4.0	Counter-clockwise
G-2	2,250	2,750	15	15	16	4.0	Clockwise

If electrical loads are to increase further and the engine builders continue to restrict the space available for the generator, the parallel operation of generators may assume more importance in the future. Numerous instances have arisen in which a motorcoach, for example, required energy in excess of that which the generator could furnish, because a large enough generator could not be mounted in the space available.

Generator Equipment Increasingly Important

On a large dirigible that is being designed in this Country it is proposed to carry eight powerplants in separate compartments. As the airship is more than 700 ft. long, the problem of transmitting electrical energy without serious loss must be considered. It is proposed that eight 110-volt generators be operated in parallel on this installation to supply one battery, all cells of which will be centrally located.

Fig. 15—Landing-Light Installation on the Loening Amphibian Airplane

The wide application of voltage regulation to automotive purposes is in the nature of a revolution and requires considerable educational effort on the part of the manufacturer. He has been handicapped severely in this respect by the slow response of vehicle builders and users. There is still some inclination to regard the generator equipment as entirely secondary in importance, in spite of the fact that it furnishes electrical energy in large quantities. A power unit which is expected to deliver 300 watts and upward is no longer a toy, and must be accorded due recognition in the automotive scheme of things. It can no longer be ignored, but must be given proper consideration and attention.

Proper Usage of Voltage Regulators

Voltage regulators manufactured today are reliable to a high degree and function automatically. In general, it is a good rule to make sure that they are properly adjusted to meet requirements and then to let them alone. In a voltage-regulated system, if the battery is fully charged the charging rate in amperes will be low. Many have assumed that a low ammeter-reading meant that the generator was not producing enough current and have raised the voltage and the charging rate, which naturally resulted in an excessively high rate with all of its attendant troubles. Instances have occurred in which the voltage has been raised, through ignorance, to more than 20 volts on a 12-volt system, despite every effort that could be made to educate the

Fig. 16—Curtiss Condor Airplane Having Two Landing-Lights Centrally Mounted

Two Generators Are Used, One on Each of the Two Engines, and the Generators Are Operated in Parallel

user to the characteristics of voltage-regulated generating equipment.

Experience has also shown that it is better to adjust the charging so that the battery is cycled frequently. This procedure has the sanction of the battery manufacturers, as longer battery life results. It is better to allow a battery to discharge somewhat and then to recharge, than it is to keep it in a fully charged condition at all times. It has also been found that in many cases it is desirable to charge the battery at higher rates in the cold months than in the warmer ones. This can be done easily by adjusting the voltage to a higher value for winter service than for summer. The automatic tapering charge still results, but the final rate will be slightly higher. The voltage should not be set so low that there is danger of the voltage of the battery, when fully charged, exceeding the generator voltage in normal operation.

Steady Voltage Benefits Lamps and Batteries

Lamp manufacturers are keenly interested in the application of voltage regulation to automotive requirements, because it assures them of less fluctuation in voltage than formerly and also is good assurance against excessive voltages which endanger lamps. By adjusting the rated voltage of the lamps to the required service-condition, it is being found that lamp life can be greatly prolonged.

Battery manufacturers favor voltage regulation because it removes, in a large measure, the chance of constant over-charging of batteries. Energy is furnished to the battery in proportion to its needs, and not at a constant rate which is excessive for a large part of the time. Some operators of fleets of motorcoaches have made the statement that battery life is at least doubled by the application of voltage regulation.

As improved methods of keeping performance records are developed by motorcoach operators, it will be possible to obtain accurate data on the cost of operating automotive electrical systems. Meager figures now available indicate that the cost of maintaining a voltage-regulated system is surprisingly low if it is not abused. The employment of voltage regulation adds no complication to the operation of the electrical system so far as the user is concerned; in fact, it should eliminate many of his troubles.

While the trend is toward the adoption of voltage-regulated generators wherever continuous operation for prolonged periods is required, it is probable that the third-brush generator will continue to have many uses. The voltage-regulated system functions automatically to protect the equipment and has many decided advantages and, where first cost is not the paramount consideration, it can be considered as the best available equipment for all classes of service known today.

Further Development in Progress

It is not to be assumed that the present voltage-regulated systems are the ultimate to be achieved. Experimental work is continuously going on to improve the performance, simplify the apparatus, and extend its application. It is believed that the principle is correct and, as more thought and effort are expended upon it, generating equipment will be further improved. During the time when both classes of generator are used, that is, the familiar third-brush and the newer voltage-regulated types, it is essential that the difference in characteristics be appreciated. Those interested should spend the small amount of time and effort necessary to inform themselves of the performance features of the two types.

The manufacturer of electrical equipment is striving to meet numerous and varying requirements, and he needs cooperation from those interested. First, the engine builder should realize that the generator equipment is no longer a mere appendage but is a power unit and must occupy a space in proportion to the service demanded of it. Proper driving speeds and means, more room, and better mounting arrangements should be provided. More and more dependence is placed on the generator not only for necessities but for luxuries which are added as features in the construction of automotive vehicles.

It is hoped that this discussion will suggest the importance of the generating unit and that mounting, space requirements, driving means, and proper capacities are engineering considerations which merit thought. Insufficient attention has heretofore been given to generating equipment. The attitude has been that a generator could be added at any time and that it was not necessarily an indispensable component to be provided for adequately. Today, generating equipment is essential on commercial vehicles, and general appreciation of this fact will give impetus to the cooperative effort needed for further improvement.

THE DISCUSSION

Question:—What are the differences between the various systems with regard to voltage control?

B. M. Leece:—A modified form of control, such as charging by current limitation until a certain voltage is reached and then tapering the charge automatically, is sometimes used. Such a system is similar to the one used on motor rail-cars. The equipment must be of fairly large size and is not well suited to the space allowed by motor-vehicle engine-builders. Some manufacturers build equipment which consists essentially of a current-regulating device augmented by series winding when the lights are turned on, which increases the output of the generator. A third-brush machine with an added series-winding in the field which is connected with the load is used. When the load is on, that increases the generator output. When the load is off, the battery charging-rate is in a measure protected.

W. M. Johnson[2]:—I recently served on a committee appointed by the Automotive Electric Association to investigate electrical loads on motorcoaches. We found that, for the ordinary size of motorcoach, of 25 to 29-passenger capacity, the battery and the generator equipment were designed to carry a load of approximately 225 watts; whereas, in service, the electrical load on these same coaches often ran as high as 350 watts. The load for double-deck motorcoaches was as high as 750 watts.

[2] M.S.A.E.—Principal automotive lighting specialist, engineering department, National Lamp Works of the General Electric Co., Nela Park, Cleveland.

There seems to be a decided trend on the part of motorcoach operators toward the greater use of electrical energy, and I believe that they should not be discouraged in this. The generous use of well-designed lighting equipment does much toward advertising the line, and toward promoting the comfort and safety of passengers who travel at night. Electrical devices, such as buzzers, fans and cigar-lighters, are other factors that help to build up patronage over that of competitive means of travel.

Since the major part of the electrical load is used for lighting, I shall say a few words about voltage. Such a wide variation exists in electrical loads, speeds, and the like, that on battery-generator systems of the constant-current type the voltage may vary 25 per cent or more at the lamp sockets, either side of normal. This means that the candlepower of lamps, which varies as the 3.4 power of the voltage, will vary from 40 to 200 per cent of normal. Their performance is, of course, unsatisfactory at either extreme. I am therefore of the opinion that we shall never have satisfactory lamp performance on either passenger-cars or motorcoaches until this tremendous range in voltage that we find in service has been materially reduced. I am also convinced from performance records we have that this range can be confined within tolerable limits by the use of voltage-regulated instead of current-regulated systems.

Trouble Caused by Overload

H. W. WILCHECK[3]:—For various reasons the motorcoach operators are looking for a larger-sized generator. They are getting tired of their present heating systems, such as by means of the exhaust. It requires a lot of current to heat a motorcoach by electricity, but it can be done.

Some motorcoaches are now equipped with electrical fans to cool them in summer. In winter driving, the front windshield becomes coated with ice as a result of the freezing of the moisture condensed on the inside glass because the temperature outside is different from that on the inside. On our next job we are going to use an electrically driven fan to keep the windshields at the same temperature on the inside as on the outside, and thus prevent the trouble.

We had trouble with the lighting system on one job in particular and found that we were using a 42-amp. discharge with a 25-amp. generator.

MR. LEECE:—On that particular job the electrical system was all right up to the time the vehicle was put on a school run where the speed did not average more than about 8 m.p.h. The generator on that vehicle was designed for normal operating conditions, but it is a problem to design a generator with which intermittent service can be furnished at an average speed of 8 m.p.h., which is all the speed will average with the stops made on a school run. The problem is not to supply current at that speed, but to provide a generator which is flexible enough to supply current when the vehicle is operated at perhaps 50 m.p.h. on some other service. That is a real problem. Had Wilcheck used that vehicle on an average service there would have been no trouble, but it was in a service requiring frequent stops which allowed insufficient time to charge the batteries.

C. T. KLUG[4]:—Voltage-regulated charging equipment favors the storage batteries and extends their life. In the long run an adequate battery of large size enables the equipment to operate at the lowest cost per mile. That is true not only of motorcoach equipment but of any kind of equipment run continuously.

QUESTION:—Will the use of a high-voltage regulating-coil make it unnecessary to use a third brush on the generator?

MR. LEECE:—Our experience is that the third-brush method protects against overload better than the regulating coil does. I think any improvements in the maximum current-output of the generator will come from a modified brush arrangement rather than from the use of a coil for regulation.

MERRITT R. WELLS[5]:—In some of the earlier types of vibrator we had trouble with the contact points. Do you experience similar trouble?

MR. LEECE:—We have had very little contact-point trouble. The reason is that, at the instant the contacts open, there is a reversal of current which suppresses any rising current due to the self-induction of the circuit. So far, the contact-point problem has been one of the minor problems in voltage regulation, provided the regulator is set to regulate the voltage within reasonable limits. If an attempt is made to run the voltage up, say to 18 or 20 volts, to increase the charging rate, this will cause trouble because the contacts and condenser capacities are not designed for that voltage.

A. J. SCAIFE[6]:—If we try to install on the motorcoach all the things for which some of the operators are asking, where are we going to put the generator? We are looking for space for it now. By the time we get through we shall have no powerplant.

The operators of motorcoaches expect to have a service man at their beck and call and, if the equipment does not perform as expected, they want it changed. They want, for example, a larger generator. If the vehicle has been designed for 8-cp. lamps, they want to change them to 25 or 32-cp. lamps and increase the load. Then, because the generator burns out, they expect the electrical equipment manufacturer to give them a new one for nothing. Such things have been going on for years. Only in one way can any of us beat this proposition. We must lay the cards on the table and tell each other what we have done and really expect to do, thus working together.

Size of Battery Required

FERDINAND JEHLE[7]:—Is the size of the battery for a voltage-controlled generator smaller than that necessary with a third-brush machine? What should be the size of the battery for a 300, a 400, or a 500-watt generator?

MR. LEECE:—The size of the battery for a voltage-regulated job is determined primarily by the amount of standby load necessary. By "standby load" I mean the load while the vehicle is operated below the effective charging speed for the generator. We have found that a 50-amp. discharge on the battery does not mean that this is all the generator should supply. In a discharged condition a battery connected to a voltage-regulated generator will require a comparatively large input, and if the generator capacity were sufficient it could deliver

[3] Berea Bus Line Co., Berea, Ohio.
[4] M.S.A.E.—Assistant sales manager, Willard Storage Battery Co., Cleveland.
[5] M.S.A.E.—Research engineer, Cleveland.
[6] M.S.A.E.—Chief field service engineer, White Motor Co., Cleveland.
[7] M.S.A.E.—Research engineer, White Motor Co., Cleveland.

an output of 100 amp. because, in addition to supplying the lighting load, it should supply enough current to charge the battery. It is manifestly impossible to design a generator of sufficient capacity to take care of the lighting loads and charge the large batteries required for standby periods; so they have to be regulated as to output in some way. The size of the battery used with a voltage-regulated generator does not matter. We do not care whether a small battery or a large battery is used, except that any charge rate from the generator must be regulated or governed to the maximum capacity of the generator rather than to the capacity of the battery.

MR. JEHLE:—In considering the installation of the battery and the generator, is not the proper solution to choose the generator for the service so that it will operate at a sufficiently low speed and have sufficient capacity to carry the entire lighting load, and that all battery charging be done in the day time, rather than to have to call on the battery to carry part of the lamp load?

MR. LEECE:—In some operations, the vehicles run entirely at night and have to stand for considerable lengths of time. Obviously, they must be lighted while standing, and usually a high discharge-rate is demanded from the battery. Then the specific gravity of the battery gradually becomes low and the generator must be able to recharge it rapidly in addition to carrying the lighting load. That immediately doubles the charge required from the generator, and space for a generator to give a reasonable amount of charge is not available.

But the worst problem is caused by the variable speeds for service; for instance, an average of 6 to 8 m.p.h. in city work and 50 to 60 m.p.h. in interurban work, the same motorcoach being used for both purposes. It is not that the generator manufacturer cannot build a machine to meet those conditions, but that they cannot be met in the small space available; there must be room for auxiliary devices. The problem will be solved, because we already have the cooperation of the motorcoach builders, who realize the difficulties as well as we do. They have been hampered the same as we have. It is not a matter of delivering to the operator a motorcoach that will meet all conditions, because that cannot be done. In industrial work we do not expect to buy a 3-hp. motor and immediately use it as a 6-hp. motor. If we do so and burn it out under those conditions, we expect to pay for it. If we buy a generator and overload it, we can expect to pay for it. Many of the operators expect to put an excessive load on the generator and then, if anything goes wrong for any reason, to call upon the manufacturer and have him make the equipment satisfactory.

National Highways

WE have now outgrown State highways for interstate use, as we have outgrown town or township roads for county use, and county roads for State use. For interstate highways there are no State boundaries, any more than there are county boundaries for State highways.

Why not profit by the experience of the past and immediately adopt the effective policy of having the United States Government own, build and forever maintain the system of 100,000 miles of United States highways now designated and being marked with the United States shield?

Our States having State highways would not today permit their counties to dictate the terms and conditions under which State highways should be built. These States would scout the idea of leaving to their counties the building of State highways passing through said counties. The Nation cannot permit the States to dictate the terms and condition upon which our United States highways shall be built. The Nation cannot permit the States to build them piecemeal. The Nation must do the work, pay for it, and afterward maintain our great system of United States highways—roads that will cover the Country with a network of primary interstate highways that will thus at one cost become the main trunk roads for the communities through which they pass. Only the Nation can build these roads heavy enough, wide enough, straight enough for our more than 30,000,000 motor-vehicles of the future and for our National industrial and military needs.

Such a system of United States highways will be paid for out of general taxation. So paid, the cost will be equitably distributed. The densely populated States and the large cities will pay most of this cost, about 90 per cent, leaving only 10 per cent to be paid by the farming communities of the West, the Mississippi Valley, the Southwest and the South. These rural areas will gain about 90 per cent of the mileage. This will result in no hardship or be unfair to the populous States and urban centers, any more than State highways have been to the cities, because, after all, they gain the most by the automatic gravitation of wealth to themselves. Let Federal aid go to the balance of the Federal-aid system as now authorized and to those parts of our 48 State-highway systems which are independent of the 100,000 miles of United States highway, as State aid is given to their 3027 counties for county, township and town roads independent of their State-highway systems.

These three systems of highways—United States, State, and local—should be built around a fourth and greater system of National highways—50,000 miles—the greatest system the world has ever seen, from capital to capital of our 48 States—industrial and military highways to carry the fast, the heavy and the thorough traffic through our Nation. This traffic would be fed to them over the system of United States highways, which in turn would collect it from the 48 State-highway systems, with which the local roads would connect throughout our Country.

By this four-fold system of highways, an impetus as yet unthought of would be given to road building throughout the Nation. Authority and responsibility would be logically and economically divided and fixed without conflict arising. Uniformity and efficiency would be established. Standards of construction and maintenance would be raised. The Nation would be given good roads everywhere by a well-balanced, connected system of National, United States and State highways and local roads reaching out to the most remote parts thereof. They would be built in a short time and with economy. The money would all go into roads and the cost would be equitably distributed upon those communities best able to pay for them.—Charles Davis, president National Highways Association, in *Motor Travel*.

Aircraft Instruments and Navigation

Discussion of V. E. Carbonara's and Lieut. A. F. Hegenberger-Bradley Jones' Aeronautic Meeting Papers[1]

IN his paper on Aircraft Instruments for Oversea Navigation, Mr. Carbonara outlined the present methods of using aircraft navigational instruments of various types and their practicability for oversea navigation. No absolutely precise instruments are avialable to determine the direction of motion and the rate of speed, which facts it is necessary to know to determine the position of a moving object. Radio beacons and goniometric apparatus are unreliable and lack sufficient range. When celestial bodies are visible, the use of the sextant and the chronometer is complicated but reliable and should be available for oversea flights. Interest in their use will be the incentive for better overseas instruments, in the opinion of the author.

Lieutenant Hegenberger and Mr. Jones emphasized, in their paper on Oversea Navigation, the necessity of proper preliminary training and preparation for oversea flights. Avigational equipment and methods of avigating will vary with each individual flight contemplated. Fatigue affects the efficiency of the pilot much less than that of the avigator, for the duties of the latter cannot become subconscious. A study of climatic conditions will decide the choice of the route flown, and the report of the meteorologist will determine the proper time of take-off. An outline of dead reckoning, astronomical observations and radio-direction as methods of avigation concluded the paper.

The discussion herewith relates to the progress in the development of equipment for aerial transportation and the problems of meteorological flight-data. Radio sets for airplane use are available in 10, 75 and 350-watt types. Radio-beacon transmitters and receivers have been developed. The problems of transatlantic weather forecasting for the flights of the last year and the need of meteorological flight-data along regular airways are presented. The discussion is closed by a statement of the needs for all-weather flying.

CHAIRMAN W. L. LE PAGE[2]:—One point in particular in connection with Mr. Carbonara's paper, the value of outside communication to aerial navigation, is very interesting to me. The weather, as such, has no direct bearing upon avigation, but it has a great influence upon the activities of the avigator and the results of his work. The extent to which radio communication is used by steamship captains on the high seas is a good indication that we shall not have reliable air navigation and air transportation without its extensive use in this field likewise.

W. G. FISK[3]:—It may be of interest to know that the Radio Corporation of America has designed three types of aircraft transmitter. In power rating, the first is a 10-watt set for ordinary use for short-flight distances; the second, a 100-watt set which is an intermediate type; the third, a 300-watt set for large types of airplane. These transmitters are arranged for both telegraph and telephone communication. It is believed that telephone communication is about 50 per cent as efficient for distance flights as code or telegraph communication would be under the same conditions.

We have also designed a beacon receiver that weighs about 10 lb. and that can be installed in the cockpit. The beacon receiver will be one of the most important developments for aircraft navigation.

The Department of Commerce is installing many ground aircraft-beacons of the 2-kw-power type at the various flying-fields in this Country. There are, at present, transmitting beacons at College Park, Md.; Bellefonte, Pa.; and Hadley Field, N. J. Two types of aircraft transmitter have been developed, one of the 400-watt type and the other of the 2-kw. type. It is generally understood that the Bureau of Lighthouses will install these beacons, as in the past the Government has installed lighthouses as an aid to marine navigation.

PROBLEM OF TRANSATLANTIC WEATHER FORECASTING

JAMES H. KIMBALL[4]:—The difficulty that the Weather Bureau encountered in undertaking to aid the transatlantic fliers arose largely from the fact that we had no common language; the flier, the avigator, the pilot, and the engineer all spoke in somewhat different terms and we hardly understood one another. Maps made in the Weather Bureau that seemed to the meteorologist to be good were treated indifferently by the fliers. On the other hand, maps that seemed to the Weather Bureau to be entirely impossible were looked upon favorably by the pilots. That is one of the situations that we should not have confronting us next year. We should find a common language in which to talk about these things so we can understand one another. There must be a wealth of value in these flights that still exists only in the minds of the fliers.

Commander Byrd and Clarence Chamberlin flew over the Atlantic Ocean in weather conditions that were similar. A tremendous area of high barometer prevailed from one coast to the other, with westerly winds. Byrd had a wind advantage of perhaps 30 m.p.h., and made his flight with great speed and directness from Newfoundland to the other side. That was a weather

[1] Mr. Carbonars's paper was printed in THE JOURNAL for November, 1927, p. 528. The author is assistant chief engineer, Pioneer Instrument Co., Brooklyn, N. Y. The paper by Lieutenant Hegenberger and Mr. Jones was printed in THE JOURNAL for December, 1927, p. 699. The joint authors are connected with the materiel division, Army Air Corps, Wright Field, Dayton, Ohio. An abstract of both papers is printed above, supplemented by a summary of the main points dealt with in the discussion.

[2] Jun. S.A.E.—Assistant to vice-president, Pitcairn Aviation, Inc., Philadelphia.

[3] Commercial engineer, Radio Corporation of America, New York City.

[4] Meteorologist, Weather Bureau, New York City.

map that looked ideal; in fact, it is the traditional summer type, a large area of high barometer over most of the ocean with relatively low pressure in the Arctic, which tends to give westerly winds from one side to the other. But Commander Byrd told us that he did 17 hr. of blind flying. We, in the Weather Bureau, were not prepared for that. We knew that the wind was right and we thought there would be no great difficulty in making the flight. We knew that there were no storms on the way, such as Ruth Elder and George Haldeman went through in their flight. The clouds through which Byrd flew were perhaps 10,000 to 15,000 ft. thick. If the Weather Bureau had known about these clouds, we would have been able to advise Commander Byrd that he would have favorable winds of good velocity but would have that blind flying to do.

Both Commander Byrd and Colonel Lindbergh flew through an area of relatively low barometer over the Newfoundland area. The pressure was only moderately low. In Lindbergh's case the low barometer was moving out rapidly. In Byrd's flight, the low barometer over Newfoundland was filling up. These two men might give us some valuable information on this particular phase of Atlantic weather. On the other side of the ocean, the storm that nearly caused disaster to the Byrd flight was a low-barometer area that developed southward from Ireland to France after he had left. This is unusual. Storms in that area usually travel toward the northeast.

At the time of the Byrd flight we had the cooperation of the British meteorologists, and I think our experience in the summer of 1927 is sufficient to convince us that a weather map of the ocean must be made through the cooperation of the American and the European services. There, again, is the need of establishing a common language, for the French record air pressure in millimeters, the British in millibars, and we in inches. There is no great difficulty in converting these, but it takes time, and this must all be done very quickly if a fresh map is to be in the hands of the flier.

Need Radio Weather Reports from Ships

One feature which resulted from the consultation with Commander Noel Davis brings me back to the beginning of the season's work. He was the first of the fliers in 1927 to ask for the assistance of the Weather Bureau. I was surprised and delighted to learn when he came to the Weather Bureau that he had studied North Atlantic weather maps for the previous 6 months. The maps were made from reports that had been received from ships for many years back. Commander Davis brought us face to face with the necessity of getting in 6 hr. a map that previously had taken us 6 weeks to make.

The Weather Bureau continues to collect weather observations from ships. They come by mail, and the map that we are making today by that process is 6 weeks old. These maps are good for study purposes but are useless for transatlantic flying. As the Weather Bureau had no funds and no personnel for the purpose, Commander Davis asked the Radio Corporation of America to collect weather reports from ships by radio, which it agreed to do. We surmounted the difficulty as to personnel during the summer, and in the period just preceding the flights we had 5 to 10 ship reports on the chart from which we could make the day's map. As delayed reports came in, we filled up the back maps and corrected the errors where we could, thus establishing a better basis for the map that was to follow.

Commander Davis called our attention to the fact that the Weather Bureau was established, in 1871, primarily for the benefit of shipping, and shortly after its establishment we were able to issue storm warnings to ships on the Great Lakes and along the Atlantic Coast. Since then we have extended the field until now we make predictions as far east as Bermuda and the Grand Banks and for the whole area of the Gulf of Mexico and the Caribbean Sea. Commander Davis argued that aircraft have as much right to such protection as the Weather Bureau can give as have marine ships. Without specific authority, we went to work and did what we could to keep the fliers out of any particular danger.

We have been able this year only to keep the fliers off the ocean when a general storm was in progress. We could not advise them as to squalls or local storms, nor have we been able to give them thoroughly satisfactory forecasts for 36 or 48 hr. in advance of the weather conditions prevailing in Europe. The fliers who were closely in touch with the Weather Bureau were able to keep out of dangerous storms with a single exception. The storm that Ruth Elder and George Haldeman encountered 36 hr. after they left was one they knew about before they left. It extended from the Arctic, crossed the steamer lanes down to the latitude of the Azores and had been moving laterally across the ocean for a week, but they decided they would take a chance. They successfully negotiated a storm that mariners class as a moderate gale, and proved the airworthiness of the 1927 type of airplane when it is handled skilfully.

Air-Mail Airway Weather Reports

Wesley L. Smith[5]:—Dr. Kimball did not mention what the Weather Bureau is doing for the Air Mail Service. Regular flying over any sort of airway has reached a point where no one starts without having a little information about the weather from the Weather Bureau. Hadley Field, N. J., has a weather map twice each day, made by Weather Bureau men from the information furnished by the Weather Bureau. We get these maps at 9 a.m. and at 9 p.m. The weather reports are collected from all over the United States by the Bureau and are sent to us at our stations. We have that service at Hadley Field and at Cleveland, and hope to have it at Chicago[6]. That weather service gives, not only local information, but information of what is coming in the next 24 or 36 hr., which is very necessary for us to know.

In addition to the reports from the Weather Bureau reporting stations, we have the local stations along the airway between Hadley Field and Cleveland that report to us as often as is necessary for the particular flights we have in mind. This service is furnished by the airways division of the Department of Commerce. Thus, two different Governmental departments are furnishing us with weather service, telling us about the weather through which we have to fly, and we correlate these two services.

One fact about the transatlantic flights of last summer is not generally known. The ill-fated attempt of

[5] A.S.A.E.—Superintendent, eastern division, National Air Transport, Inc., Cleveland.

[6] This service is now furnished at Chicago, also.

Mr. Bertaud and Mr. Hill, who were former Air Mail pilots and my associates, was made to demonstrate that it is not necessary to wait for favorable weather to fly. The pilots did not wait for good weather. We have learned that, with the proper instruments, it is possible to fly through any kind of weather, aside from a freezing rain or mist that forms ice on the airplane. But it is impossible to land unless a safe landing-place can be seen. These men planned their flight to demonstate that one could say, "We are going to start at 9 a.m. on Tuesday of next week," and start. Their airplane was loaded so heavily that they needed a 20-mile wind to enable them to get off the ground. They waited a long time for that wind, but engine failure ended their flight disastrously.

We have learned in the flying we have to do in the Air Mail Service that weather where we are is not of interest to us. We are interested in the probable weather condition at our destination 4 hr. later. This is why we are anxious to have these weather charts from the Weather Bureau and the reports from the Department of Commerce.

L. R. PALMER[7]:—What success do you expect with the radio beacon that is being installed at Bellefonte, Pa.?

MR. SMITH:—We expect to experiment with it as soon as possible. We have been operating only since Sept. 1 and our equipment is not yet up to the standard we need for ordinary flying. The Air Mail Service had one or two airplanes equipped to work with the radio beacon but did not carry the tests very far. We plan to go as far as necessary along this line as soon as the equipment has been installed on our airplanes and is ready for use.

MR. FISK:—The radio beacon at Bellefonte has been used by the Army pilots in airplanes and is proving very satisfactory. The Radio Corporation of America is cooperating in developing that beacon.

SAFETY COUNCIL INTERESTED IN SAFE FLYING

MR. PALMER:—I may say, as a member of the aviation committee of the National Safety Council, that the committee is interested in any improvements that will make flying safer. We have had some disturbing months this last summer so far as strict safety is concerned, but we have been loyal to the new industry that is being established, and our criticism, if we should make any, would be constructive. To establish our safety work on a constructive basis, we persuaded Harry Guggenheim to present, at our congress in Chicago, a paper which was distributed throughout the Country. This was accompanied by a resolution from the National Safety Council supporting, in every way, the men in this new industry. We have records of the fatalities, but we also have the knowledge that in all new industries the pioneers must pay the price. It is gratifying to us to note the remarkable reduction in the fatality rate under the careful supervision that is now being given. In one year 20 pilots were killed. In 1926, under Governmental flying, only two were lost in the Air Mail Service. The report that is coming out from the Department of Commerce indicates a splendid reduction in the fatality rate. The National Safety Council is pledged to support the Department in any way it can.

Regarding the radio beacon, I flew from Los Angeles to Salt Lake City and I know that the splendid pilots on the Western Air Express are much interested in the development of that service. I flew from Portland to Seattle in a Fokker Universal. The stations are radio-equipped and I understand, the airplanes are now being radio-equipped. Anything that can be done to speed up the installation of practical equipment along this line will be praised by safety men.

EDWARD P WARNER[8]:—At the Aeronautic Meeting in Philadelphia in 1926, Mr. Smith gave us a valuable description of the methods of flying that he and his associates were using over the eastern section of the Transcontinental Airway. It was an evidence that blind flying by dead reckoning and observation of landmarks by day and by night was being pushed to the limit of possibility, and I assume beyond anything that has been attained anywhere else in the world. It would be of great interest if Mr. Smith would say anything, not so much about the prospect of radio and astronomical avigation or any other auxiliary method of avigation, but about what he regards as the necessary specifications to be met to supplement with advantage the procedure that is now being employed on the commercial airways.

AIDS NEEDED FOR ALL-WEATHER FLYING

MR. SMITH:—The things we need are not many. The radio beacon is supposed to give a line of direction on which we can stay when flying and that will enable us to correct for drift. That, I think, is as far as we can expect the development of the radio beacon to go. In addition, we need something to improve the condition of landing when there is no visibility. It is possible to land at night through a ground fog if the lights show through it, but we need something better than lights where the fog may be 5000 or 10,000 ft. thick; for instance, a cable stretched around the field or at angles to the field that will transmit a signal which can be picked up by the radio equipment in the airplane. We also need an altimeter that will register exactly the height of the airplane above the ground. Our present instruments depend on the change of atmospheric pressure with altitude. They do not register the altitude except over the starting point or the destination if the barometric reading of that point is know before starting and the instrument is set for it. An altimeter that would tell exactly how high the airplane is above the ground at any moment would be of great assistance, especially in trying to land through a fog where nothing is visible.

R. W. A. BREWER:—Can you obtain any height reckoning from the reflection of sound? You mentioned something in Philadelphia about it.

MR. SMITH:—Unfortunately, the engine and the wires, the propeller and other things on the airplane make so much noise that the pilot cannot hear any sound outside unless it is a clap of thunder or something on that order.

R. T. PIERCE[9]:—Weight plays a very important part in the selection and design of equipment used for airplane service. Often, however, it seems that quality and other things are sacrified to save a little weight. The galvanometer used with the earth-inductor com-

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[7] Past president, National Safety Council, New York City.

[8] M.S.A.E.—Assistant Secretary of the Navy for Aeronautics, Navy Department, City of Washington.

[9] Instrument section, Westinghouse Electric & Mfg. Co., Newark, N. J.

pass is an example of this. Our experience has been that light-weight elements in small cases, with the pointer and other parts of the moving system relatively short, tend to pick up vibration from the rest of the airplane, since their natural period of vibration is rather high. Sometimes the oscillation set up in the instrument pointers by these vibrations makes them inoperative or gives false readings. If it were permitted to use a slightly heavier movement, distributing the extra weight in the length of the pointer, so that the natural period of vibration would be lower, a more stable instrument probably would result. This would mean that the other parts also would be slightly heavier and that the instrument would take up more space on the dash. However, if this were permitted, the instrument would be more reliable.

Effect of Pressure on Oiliness

THE people of this Country pay about $650,000,000 a year for lubricants. They also pay a bill which probably amounts to several times this amount each year for wear and tear resulting from the use of improper or insufficient lubricants on valuable machinery. The compounding of lubricants from the many different mineral, animal, and vegetable oils available has been largely empirical, guided by a knowledge of the desirable viscosity or body of the oil for a given condition and the effects of temperature on the oil. There has still remained an indefinite factor which differentiated certain oils as better lubricants than others. This factor has been termed "oiliness," but until recently the reason for this superior performance of certain types of oils has been a complete mystery and the relative value of the various oils has been much disputed.

At the lubrication session of the American Society of Mechanical Engineers last December, there was brought forward the result of certain researches that appear to have solved the problem of "oiliness." It was shown that the viscosity or body of various oils changes with pressure in a very interesting way. Those oils that are generally regarded as the best lubricants stiffen rapidly when pressure is applied to them. A number of the vegetable oils, including castor-oil, have the required increase in viscosity at low pressures, but at somewhat higher pressures they cease to show the characteristics of good lubricants. In fact, certain oils, notably the best so-called "cutting oils," are able to freeze solid, due to the application of pressure, even at temperatures many degrees above their normal freezing points. Indications are that this freezing as a result of pressure takes place even when these oils are mixed with non-freezing oils such as the mineral oils, and this accounts for the efficacy of the so-called "mineral-lard" oil combinations. On this particular phase of the subject, however, there is no conclusive information as yet.

The technical data so far obtained show the wide variation in behavior of certain typical oils. The additional data necessary before complete results of commercial importance will be at hand, will probably be obtained in the near future, although the completion of the work is temporarily checked by lack of funds. We may confidently expect, however, that within a few years at most there will be a marked change in the methods of compounding lubricants and in the effectiveness of the products, especially in those fields where heavy loads and high temperatures are encountered. The better insight into the field of cutting oils will doubtless make both cheaper and better lubricants for this service. And in the field of machine operations, thousands of horsepower will be saved and higher speeds realized as the result of intelligent understanding of the characteristics of various oils on which their "oiliness" depends.—Industrial Bulletin of Arthur D. Little, Inc.

Refiners Should Play Ball with S.A.E.

MORE and more refiners are falling in with the recommendations of the Society of Automotive Engineers that motor oils be labeled with the appropriate S.A.E. Viscosity Number as well as the brand name.

The S.A.E. system consists of a series of six numbers, each designating viscosity range within fairly close limits. For heavy oils, the viscosity indicated is that at 210 deg. fahr.; with lighter oils at 130 deg. fahr.

The system represents the attempt of automotive engineers to get a closer approach to uniformity in motor-oil viscosity than is possible with the arbitrary designations of light, medium, heavy and so forth.

We think this is a good thing. Cooperation between the automobile engineers and the technologists who manufacture the oil to lubricate the cars should work to the benefit of everybody concerned.

Some refiners still are holding out against recognition of the S.A.E. Viscosity Numbers. It is hard to see how printing or stenciling on can-label or barrel-head the legend S.A.E No. 50, for instance, in addition to the manufacturer's brand name, could detract from the individuality of the brand.

It would seem that the S.A.E. specifications are reasonable, that they allow a rational tolerance, that they are not hard for refiners to meet. Some of the cars being turned out today offer a serious lubrication problem. These are the cars built and widely advertised for their ability to travel at very high speeds. At best, the life of such cars, if they are actually driven fast most of the time, is much shorter than that of slower-driven cars. Failure of lubrication in such cars is simply disastrous.

These cars are expensive and their buyers are mostly men who expect perfect performance for their investment and who kick strenuously if they do not get it. The automobile manufacturers cannot afford to displease such customers, so they specify carefully the oil that is likely to give most satisfactory service in high-speed, expensive cars. This was the main reason for the formulation of the S.A.E. specifications by the automobile engineers.

As the high-speed cars become more numerous and the lubrication problems more severe, it may be that the automobile manufacturers will be driven in self-defence to urge buyers of their cars to use certain oils, by name, which comply with the S.A.E. recommendations. This would be embarrassing and unpleasant for everybody concerned.—Editorial in *National Petroleum News*.

The Production Engineer's Task

By CHARLES B. EKDAHL[1]

BUFFALO SECTION PAPER — *Illustrated with* DRAWINGS AND PHOTOGRAPHS

MASS production and commercial competition have combined to lend great importance to modifications of motor-vehicle design and so have developed new types of engineers known as tool engineers and production engineers, who take the ideals of automotive engineers and convert them into practicalities, so that the design becomes an ideal manufacturing project that makes it possible to produce a car economically.

Special tools are required for many of the machining operations, and for the designing of these the more intelligent and skilled of the workmen are developed into tool-makers for the making of fixtures, jigs, dies, gages, cutters, and punches. Gradually the better tool-makers became tool designers and transferred their work from the bench to the drawing-board, becoming twin brothers of the automotive engineer. Of late, the designing and building of special equipment and allied work have entered into the duties of the tool designer.

The author describes some of the tool engineer's duties and responsibilities, indicates by a table the magnitude of the machine equipment of a modern automobile plant, and illustrates some of the special machines and processes.

THE tremendous growth in automotive production during the last 20 years has given birth to problems in automotive design that were not even thought of in the early days of the industry. In those days the engineer gave no thought to any manufacturing problems that might be involved in actually producing the car which he laid out on the drawing-board so deftly. His chief concern was to design a car that would run.

[1] M.S.A.E.—Chief tool engineer, Pierce-Arrow Motor Car Co., Buffalo.

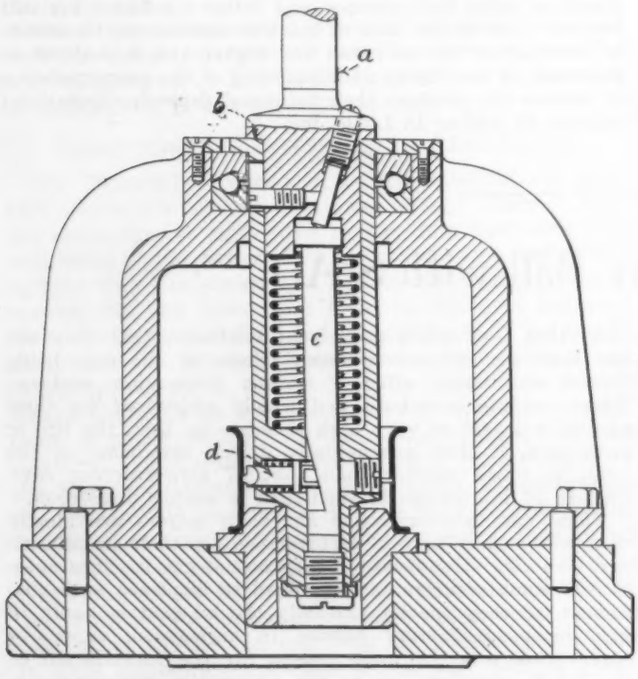


FIG. 1—FIXTURE FOR CUTTING ANNULAR OIL-GROOVE IN CONNECTING-ROD CRANK-END BEARING

This Tool Is Used Under a Drill-Press. The Shank *a* Is Held in the Spindle and the Tool Is Brought Down Against the Stop *b*. With the Setting Downward of Rod *c*, the Cutting-Tool *d* Is Forced Radially Outward and Cuts the Ring Groove. When Shank *a* Is Raised, Springs Force the Cutting-Tool *d* Out of the Groove and the Tool Is Ready To Receive Another Bearing

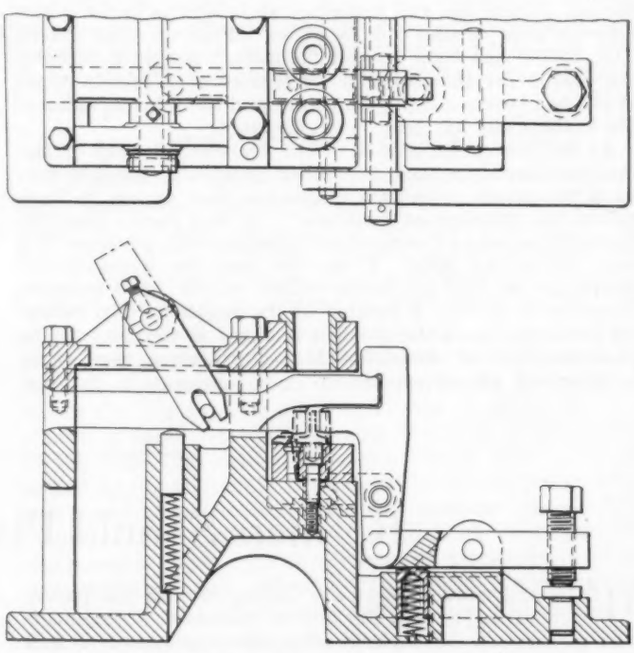
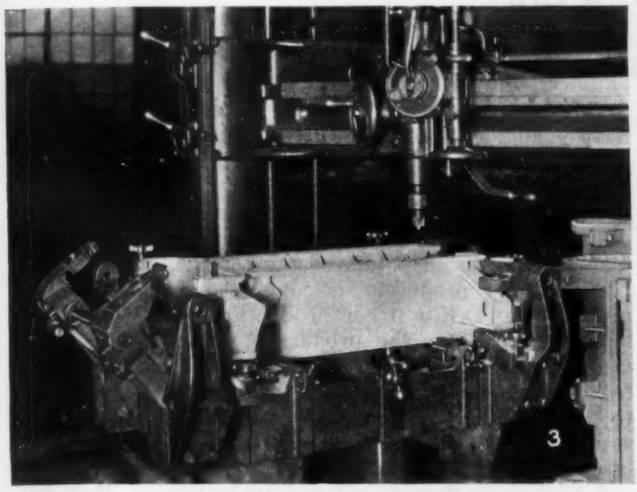
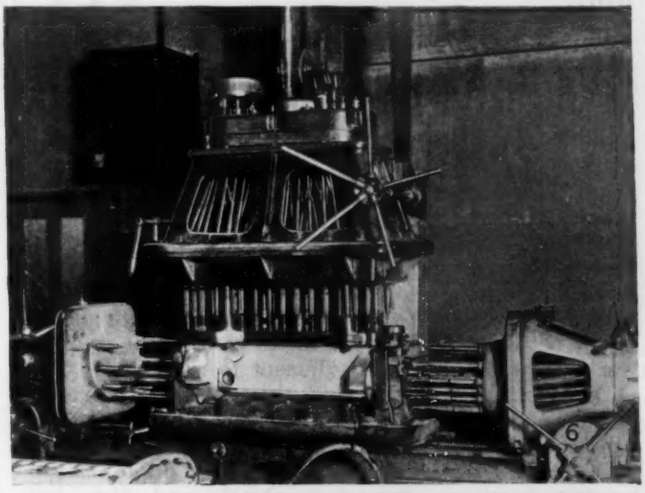


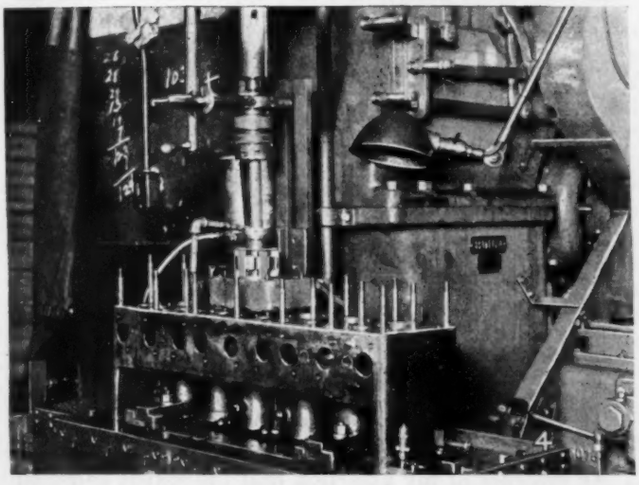
FIG. 2—NOVEL CLAMPING METHOD USED IN JIG FOR REAMING VALVE-LIFTER GUIDES

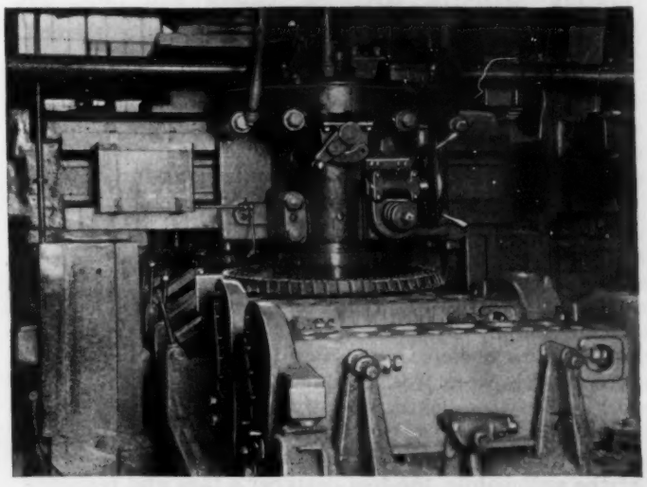
It is one thing to design a car that is ideal so far as performance and beauty are concerned; but it is quite another problem to design the car so that it represents an ideal manufacturing project. By this I mean a car that can be built economically.

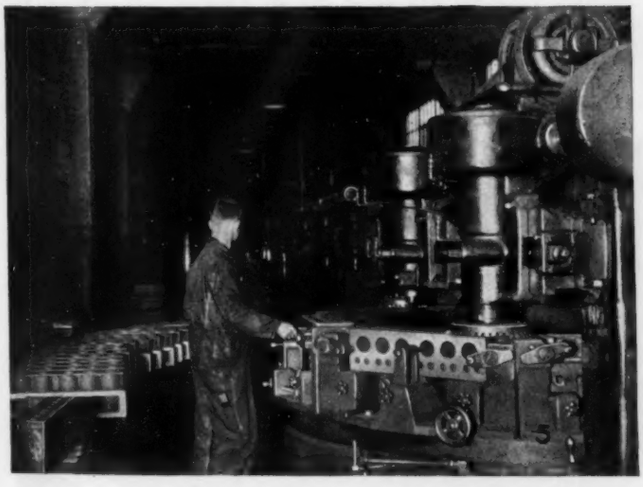
The very important task of influencing modifications of design to make possible more economical production has developed new types of engineers, known as production and tool engineers. With no intent to disparage the great achievements of automobile engineers, I may say that these production and tool engineers take the ideals of automotive engineers and convert them into practicalities.

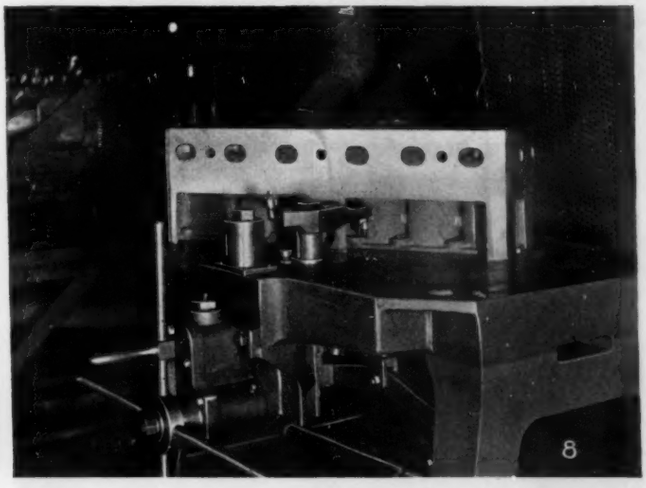












Some of the Pierce-Arrow Equipment for Machining Cylinder-Blocks and Crankcases

Fig. 3—Fixture for Inspecting and Work-Spotting Crankcases. This Determines Whether There is Sufficient Stock at All Points To Enable the Crankcase To Be Machined to Specifications. It also Drills and Faces Accurately for Work-Spots To Be Used for Locating Purposes through the Succeeding Milling Operations.

Fig. 4—Honing Bores with a Barnes Cylinder-Honing Machine Equipped with Hutto Grinder. Stroke of the Hone Is Controlled Hydraulically. Roundness and Smoothness of the Cylinder-Wall Can Be Held within 0.005 In.

Fig. 5—Milling Eight Cylinder-Blocks Simultaneously in a Newton Milling-Machine, One-Half of Which Is Seen in the Foreground. The Machine Has Two Rough and Two Finish Cutters, Two of Which Are on the Reverse Side. The Four Surfaces of a Cylinder-Block Are Milled in 15 Min.

Fig. 6—Drilling Holes Three Ways in a Crankcase. This Is a Standard Baush Machine Equipped with Special Cluster-Plates and 55 Drills.

Fig. 7—Milling Top of a Crankcase with a 32-In. Cutter. Machine-Tool Builders Asserted a Few Years Ago That It Was Impossible To Use a Cutter of This Size, but Pierce-Arrow Is Employing It Successfully.

Fig. 8—Cylinder-Block Facing Machine Designed by Pierce-Arrow Company. This Special Machine Was Designed To Reach the Remote Locations of the Cylinder Hold-Down Studs.

Much that has been said regarding loss of mechanical skill should be modified, because the volume of manufacturing required by mass production, forced by the great consumption, could not be accomplished by the number of skilled workmen available now or in former years. Instead of centering our hopes and efforts in the training of additional forces of skilled mechanics, which would require one or more generations, we have accepted conditions as they were and segregated the more intelligent and skilled workmen from the unskilled workmen. We make use of the brains and skill of the better qualified mechanic to provide the ordinary workmen with superior equipment to be used by them as a substitute for the skill they lack. Tool-makers have been developed from the class of skilled mechanics, and their product is known as tools.

The term "tools" should not be thought of as embracing hammers, wrenches, chisels and files, but, rather, intricate apparatus called fixtures, jigs, gages, cutters, punches, and dies.

The extent of the use of these special tools is not fully known to many, I believe, except those who are specifically acquainted with them. The absolute need of special tools became evident when mass production of articles of high quality was required, as for instance, fire-arms, sewing-machines, typewriters, bicycles and, later, electrical apparatus, automobiles and aircraft.

Development of the Tool Engineer

Gradually from the tool-maker developed the tool designer, mainly from the best of the tool-makers, from those who excelled in their ability to invent and construct. His work was no longer done at the bench, but at the drawing-board, and thus the tool designer became the twin brother of the automotive engineer. While the latter's duty is the engineering of the design of the automobile, the tool designer's task and responsibility lie in the engineering of ways and means to produce the parts of the automobile, and not only to produce them, but to produce them quickly, accurately and economically.

Of late, the designing and building of special machinery, equipment, means of transportation, layout of factories, rotation of work and sequence of operations have gradually entered into the duties of the tool engineer, who more often is properly called the production engineer.

Creation takes time. After six months or more of designing, secretive experimental work, and many mysterious trips to all points of the compass, the automotive engineer produces his completed design, and the management O.K.'s it for production. Then the usual troubles begin for the production and purchasing divisions, the machine-tool builders and the tool manufacturers. At this stage the sources of supply have to be established, sequence of operations determined, supply of small tools, machine-tools, special machines, layouts of machine and conveying systems provided, and floor space determined and apportioned. Most important of all is the designing of special tools.

In designing new special tools, the tool engineer clings to the principles that have been successful in the past. He also embodies new ideas that have been developed and stored in his mind as a result of experience since the last set of tools was put into use. He must ever adjust himself to advancements in machine-tool building, he must cope with the introduction of new material, and his designing must keep pace with the general onward march.

Some conception of the magnitude and difficulties of his task can be gained from a few examples of special machine-tools and fixtures in use by the company with which I am connected, as shown in the accompanying drawings and photographs, Figs. 1 to 9, with their explanatory captions.

Difficulty of Estimating Tool-Equipment Cost

As evidence of my assertion that the extent to which special tools are used for automobile parts is rarely realized, the following list indicates the difficulty of estimating the total cost of a tool equipment needed for the production of the component, or even the individual,

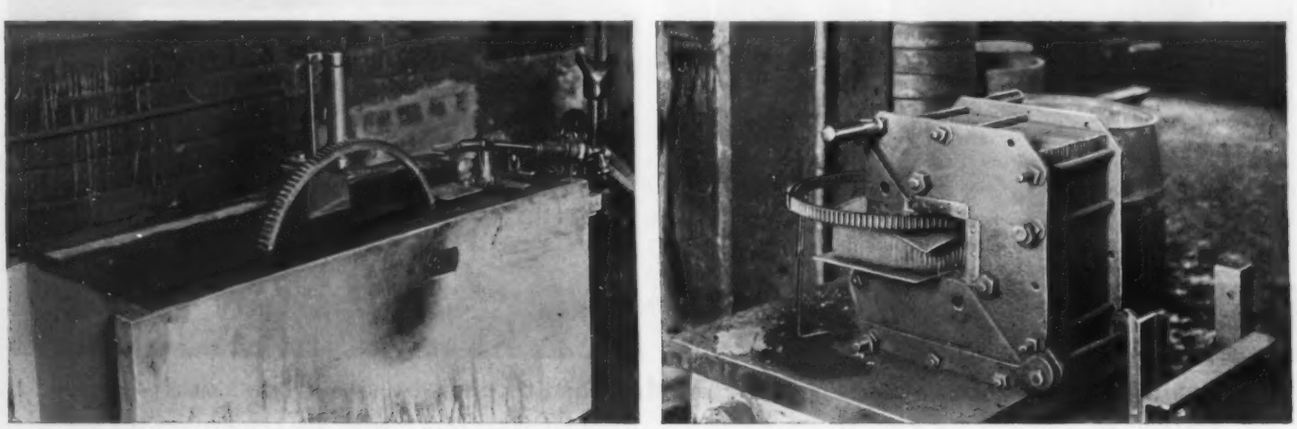


Fig. 9—Hardening and Expanding Starter Ring-Gears

The Engine-Starter Ring-Gears Are Hardened in the Machine at the Left, in Which the Gear Is Driven by a Geneva Motion Operated by a Chain from a Variable-Speed Motor. The Motion Is Adjusted To Allow a Gas Flame To Heat about One-Quarter Length of Gear Tooth for About 2¼ Sec. and Then Automatically Rotates the Ring To Lower the Heated Tooth into the Cooling Bath. This Hardens the Teeth about ⅛ In. Deep. The Time per Gear Is 4¾ Min. and the Material Is S.A.E. Steel No. 1045. When the Ring Is To Be Applied to the Flywheel, It Is Expanded in the Electric Heater Shown at the Right, Then Placed Over the Flywheel on a Plate Holding-Fixture and Cooled Under Jets of Water, Shrinking It in Place. This Heater Is Hinged at the Lower Right So That the Upper Right Half Can Be Thrown Back for Insertion and Removal of the Gears. The Coil in the Machine Acts as a Primary Winding and the Ring-Gear as a Secondary Winding. The Gear Is Held Between the Contacts about ½ Min., and Is Heated to from 400 to 450 Deg. Fahr., Which Expands It about 0.030 In. The Shrink-Fit Allowance Is 0.018 In.

NUMBERS OF TOOLS USED FOR WORK ON CYLINDER-BLOCK OF SERIES-81 CAR

Permanent Tools		Perishable Tools		Number of Machines	
Milling Fixtures	8	Gages	22	Continuous Rotary Mill	1
Drill Jigs	10	Milling-Cutters	4	Multiple Drills—12 Spindle	4
Tapping Fixtures	4	Drills	154	Multiple Drills—39 Spindle	3
Cylinder Boring Bars	18	Reamers	90	Multiple Drills—21 Spindle	1
Spindle Heads	3	Taps	106	Multiple Drills—22 Spindle	2
Cluster Plates	5	Spot Facers	24	Cylinder Borer—6 Spindle	3
Honing Fixtures	2	Special Wrenches	7	Drill Press—Single Spindle	4
Grinding Fixtures	5	Cutter Blades	148	Drill Press—Radial	1
Miscellaneous Tools	41			Facing Machine	1
Total	96	Total	555	Cylinder Grinders	5
				Honing Machines	2
				Power Press	1
Layout Drawings	7			Valve Grinder—12 Spindle	1
Tool Drawings	110			Total	29

parts of a car. Small tools, such as cutters, drills, and reamers, generally are designed along old established lines. Much equipment of the sort shown in the center column can be procured from stock, but the items of the first column require separate consideration, as a slight change in the design of any one of the several parts may require an entirely different type of jig or fixture.

These jigs and fixtures must be made to a tool drawing which must be self-explanatory to the tool-maker, as the foreman cannot be expected to study the drawing and answer questions asked by his men. Further, much of this work is sent, of necessity, to outside tool-making concerns. Although it is customary for an automobile plant to maintain a toolroom, not only for the making of new tools, but particularly for the purpose of keeping existing tools in condition, it would be most unexpected for it to keep a large toolroom manned and equipped to handle a large volume of tool work quickly and periodically.

In the last column of the table are shown a number of special machines which are built by a small number of machine builders whose experience is to their credit and to the advantage of the automobile manufacturer. These machines are not specially built in their entirety, but must be modified for each automobile manufacturer. As the factor of time of delivery is of foremost importance, it often becomes necessary for the tool engineer to change his intentions regarding certain types of machine. In the selection of special machinery he must give consideration to the probable necessity of re-equipping in the future, and avoid purchasing machines that may become a total waste in event of a change in the design of the part on the production of which the machines are to be used.

I wish to call particular attention to the fact that, unlike the automotive engineer, the tool engineer is not afforded an opportunity to experiment or try out his work. For this reason he must be fully acquainted with manufacturing methods, tool-making, and machine building. His training is not so much by academic methods as by practical experience, and he is, for the most part, recruited from the ranks of mechanics. As all education is based on experience, whether obtained from books, schools or through observation, the engineers of both branches referred to are brothers in effect. It is to their mutual advantage and to the benefit of the manufacturer for them to regard themselves as such. There should be no contention among them, except the striving of individuals to excel.

THE DISCUSSION

FLOYD LOWELL[2]—The machine-tool business has progressed more in the last 10 years, I believe, than it did in all the time previous to that period. We appreciate that the manufacturer has a problem, and, for this reason, the machine-tool builder is cooperating with the tool engineer in every way possible. In the last few years machines with anti-friction bearings have been developed. This was thought impossible a few years ago. The same is true of grinders. All of this has a tendency to increase production and cut down costs.

The outstanding machine-tool today is the centerless grinder, which I believe the automotive engineer should keep in mind when designing. While it is possible to do many things with this machine, once in a while the automotive engineer will put a wart on a part which will prevent it from going through the grinder. It may interest you to know that balls are being ground today on the centerless grinder, and the use of this machine in the ball industry alone will reduce floor space about 75 per cent and give greater production. The machines are also grinding roller-bearings and doing taper work. We are taking a fiber square and grinding it round. Before the introduction of the centerless grinder, these fiber bars were put through a type of doweling machine. As fiber is very abrasive, it was a costly job. One plant is grinding this fiber at the rate of 70 ft. per min. Pistons are ground at the rate of about 175 per hr., the grinder removing about 0.005 in.

WHY TOOL WORK IS SENT OUT

QUESTION:—What is the reason for sending so much tool and die work outside when you have equipment of your own to do the work?

CHARLES B. EKDAHL:—It is a question of additional overhead, time and capacity. The usual automobile plant has a toolroom that is run normally; the plant cannot maintain a force large enough to take care of all the tooling required when a new model is about to be

[2] Buffalo representative, Cincinnati Grinders, Inc., Buffalo.

produced. The toolroom in most plants is merely a maintenance division.

HANS BUERK[3]:—Tool-making, like many branches of the automobile business, has become a specialty. Automobile companies do not make their own springs, bodies, wheels and other parts. Why should they make tools? This is true, not only in automobile factories, but in other industries. I agree with Mr. Ekdahl that it would be very costly for the automobile manufacturer to maintain a toolroom large enough to take care of his work. It is a problem merely to get the men on short notice. By the time he could get the men, the period for the work would be past. Typewriter companies have toolrooms only for maintenance work. Suppose a manufacturer of adding machines has designs for a new machine. Probably $500,000 worth of tools will be required. He would have no chance whatever to manufacture those tools in his own shop, so he is forced to send this work out. Then it is a question whether outside tool-makers can design tools that are satisfactory. This is where the tool engineer comes in. He must make drawings that can be read by everyone in the business. The man in the tool factory does not know the peculiarities of the adding-machine factory, nor has he the experience that is back of that concern. If a plant wants to have good tools made, it should be careful to send the tool-maker good drawings.

I want to call attention to the efficiency that, of necessity, grows in a tool shop. A great variety of work goes through a jobbing tool-maker's hands, and he collects valuable experience that the tool foreman in a factory never gets, because the foreman is not in touch with the outside world; so the outside tool-maker is more uptodate. Our tool-makers do very accurate work. I know a typewriter manufacturer who sends his work out because he feels that his men cannot make the tools accurately enough. I know that the practice of making tools outside will grow, because it is based on common sense and, moreover, it is a necessity.

QUESTION:—What does Mr. Ekdahl regard as the average life of some of these tools? Do they become obsolete from heavy use, or from a change in design?

MR. EKDAHL:—The life of a machine-tool is determined by the production. For instance, the life of the multiple drill should be about 10 years if the drill is taken care of properly. The life of jigs and fixtures depends on keeping them in repair. That of cutting-tools is governed mainly by the amount of use given them and the speed at which they are run. Some factories regrind their tools at night, to have them ready again in the morning.

[3] Tool manufacturer, Buffalo.

Distribution Undergoing Transition

PRODUCTION has grown so rapidly that it is flooding the old channels by which goods found their way from producer to consumer, resulting in the most relentless and, in many cases, the most destructive competition business has ever known. While the costs of manufacturing have been reduced, the costs of distributing products threatens to offset these economies. Business is beginning to realize that it is spending too much in selling what it has made.

Distribution is in a transition stage today. There was a time, not so long ago, when distribution followed the direct route: manufacturer to wholesaler, wholesaler to retailer, retailer to consumer. Competition was between dealers engaged in the same kind of business and laws were passed to prevent the formation of "trusts." We have outgrown all this, or most of it, and today we have the super-association for the purpose of mutual benefit through studies of economies and better merchandising practices. Methods of distribution of immense importance and wholly different from other methods are appearing with almost the rapidity of mushrooms, but with the sturdy and substantial nature of the oak.

There is still another tendency which must be contemplated in considering the basic facts in distribution: Wholesalers are becoming manufacturers; retailers are combining successfully to perform the wholesale function for themselves; and wholesalers are becoming not only manufacturers but are establishing their own chains of retail stores. Department stores are forming into chains; and, undoubtedly, there are other instances of change which will excite our amazement when they are recognized. Much of this is due to the need for wider and greater distribution brought about by the increased productive facilities which were born of the demands for military supplies during the war. While our population has grown, it has not been able to assimilate the entire output of our factories, as a consequence of which there has been immense effort to discover new methods of sale.—From an address by Alvin E. Dodd before the Ohio Petroleum Marketers' Association.

Airplane Speed

ALTHOUGH the present average speed of the airplane has been given as 90 m.p.h., the possibilities for the future are beyond safe prediction. Even while we are discussing this subject here, the speed is being increased an additional 30 m.p.h. for commercial work. Within the next few months an air passenger-service will be inaugurated between Los Angeles and San Francisco, and the cruising speed of the airplanes will be 120 m.p.h.

As you all know, man has already flown at a speed of over 300 m.p.h. Although it seems fantastic to us to conceive of traveling commercially at that speed today, nevertheless the history of the past and especially the history of aviation is evidence that the fantastic of today becomes the commonplace of tomorrow. The training plane that I flew in 1916 had a maximum speed of about 65 m.p.h., and at that time the speed of 120 m.p.h. seemed just as much beyond the realm of possibility for commercial purposes as 300 m.p.h. today.

In traveling at high speed in the air, one point which those who have never flown have great difficulty in appreciating is the absolute unconsciousness of speed.—Harry F. Guggenheim before New York Railroad Club.

Trends in Body Design

By HERMANN A. BRUNN[1]

DETROIT SECTION PAPER *Illustrated with* PHOTOGRAPHS

THE trend of body design is a large subject. I have been wrestling with it for several weeks and have failed to put it on its back. Of the many ways of designing bodies, I have discovered that two are very important; one is to design a very beautiful outline and then to attempt to lay out the seating arrangement; the other, which I think is preferable, is to lay out the seating arrangement first, being sure to provide adequate room for all the passengers and for their legs, arms and heads, and then surround it with an outline. Remember, there is no substitute for comfort.

A friend of mine commented recently on a body designed so that it was very difficult to get into the front seat and very uncomfortable after a person was seated. He said, "This must have been made for a cripple, or, if not, it will make cripples out of those who use it."

You will laugh when I say it, but you cannot cut a piece off of the passenger. He wants to take his legs, arms, body, clothing and hat with him, and he may even want to carry some luggage.

Many automobile bodies are so small that, when five grown people wearing overcoats and hats are in them, the automobile seems to disappear. All one can see is the passengers, who appear to be spilling out. They seem to be on it, rather than in it. Of what practical value is a car, be it ever so beautiful, if it is not useful? One of the trends certainly will be to make the passengers more comfortable. I do not see how it is possible to continue body designing without paying more attention to this feature.

Why do body designers copy one another's designs so slavishly? If each could give his car distinction it would be much better than to do as has been done with a car brought out a year ago. So many cars like it are now on the streets that it seems as if I see them everywhere.

A few years ago the chassis was too high from the ground. The chassis builder did not seem to give the artistic side of his job enough attention. Consequently, the appearance of the completed vehicle was not very pleasing. It was too high. What happened? The automobile manufacturer got after the body builder hammer and tongs to make the body lower, to keep the roof down, and to put the floor down between the side frames. But he was attacking the problem in the wrong place. Head-room and visibility suffered through this effort.

The body is made for the purpose of carrying human beings, no matter what is the height of the chassis from the ground. The passenger wants good visibility, which cannot be attained if the roof is too low. I was in a car recently with five persons. The instrument-board seemed to be right in my lap. The car had huge pillars and a roof so low that I could not see out. It was depressing. I had ridden in other cars that had good visibility and plenty of head-room, in which it was much more pleasant to ride. Now that the chassis has been lowered, I do not see why we should not stand out for enough head-room, and enough length and width, and for small pillars.

Some of the recent styles in body design of the company with which I am connected are shown in the accompanying illustrations. Fig. 1 shows a five-passenger sedan, Fig. 2 our all-weather semi-collapsible cabriolet, Fig. 3 our five-passenger sedan-landaulet, and Fig. 4 our sport convertible-phaeton, which will be described later. The view in Fig. 5 represents the all-weather town brougham. The rear of the all-weather semi-collapsible cabriolet shown in Fig. 2 is illustrated in Fig. 6, and the rear seat of the all-weather town brougham in Fig. 5 is shown in Fig. 7.

There is no substitute for comfort.

Of what practical value is a car, be it ever so beautiful, if it is not useful? One of the trends of body design certainly will be to make the passengers more comfortable.

You cannot cut a piece off of the passenger. He wants to take his legs, arms, body, clothing and hat with him, and may even want to carry some luggage.

Many automobile bodies are so small that, when five grown people wearing overcoats and hats are in them, the automobile seems to disappear. All one can see is the passengers, who appear to be spilling out.

These and other gems appear in Mr. Brunn's paper, which possesses high inspirational as well as practical value.

SIMPLIFIED DESIGNS HOLD FAVOR LONGER

The exteriors of bodies can be simplified considerably. Fewer moldings can be used. Making a good outline on a drafting-board is only the inception of the design. The outline may be very pleasing but the side-sweep and turn-under may be very ugly; consequently, the body is not attractive. With a good outline and with care and attention given to shaping the side-sweep and the turn-

[1] M.S.A.E.—President, Brunn & Co., Inc., Buffalo.

under, the appearance is satisfactory from almost any point of view.

Another reason for simplifying the design is that it becomes a more lasting one. Many have had the experience of purchasing something that seemed to be very attractive but which soon made the purchaser wonder why he bought it. In other instances, the purchase grew and grew in favor, as any splendid piece of craftsmanship does. Why should we not simplify design? We would not need to change designs so frequently. The more ornate the designs are, the sooner they pass out of the picture.

The chassis maker should pay more attention to hiding the anatomy of the chassis, especially in the rear. Many makers are now doing this. More attention is paid to it in Europe, and we all should take more interest in the front and the rear of the chassis. An example of clean-looking rear-end design is shown in Fig. 6.

I am a firm believer in making the windshield pillars and other pillars just as small as is consistent with strength. Increased visibility makes for greater safety in driving, and a feeling of satisfaction and pleasure is given by a car that has plenty of head-room and good visibility which cannot be given by a small, narrow, cramped vehicle. A good example of small windshield-pillar construction is shown in Fig. 1. The pillar is one of the smallest ever made; it presents only a 2-in. obstruction to the driver's vision.

The fixed windshield-visor has outlived its usefulness. We cannot continue much longer to expect the driver to stoop and twist his neck to see underneath a solid visor. Visors should be made of a neutralized glass that protects the driver and which can be adjusted from the inside. I have seen some bodies lately which have no visors, only a curtain on the inside.

Safety glass should be considered, not only for small cars but for large ones. Persons riding in inexpensive cars want protection as much as do those who buy expensive ones. Perhaps such glass would cost more, but I believe the public would pay for it.

Adjustable Seats and Form-Fitting Upholstery

Adjustable seats, both front and rear, are bound to win their way in public favor. An unadjustable seat is at best a compromise. How can we make one permanently fixed seat that will suit the passengers of various sizes? An adjustable seat assures a driver or a passenger, whether he be tall or short, lean or fat, a comfortable seat. It should be made so that he can adjust it while he is riding, because it is an added advantage to be able to shift the seat to change one's position without stopping the car. I think this is applicable to the rear seat also. To be able to tell a prospective purchaser that he can adjust the seats is a great selling point. It wins a smile immediately.

Upholstery should be more form-fitting. Instead of having just a little flare, made up of almost straight lines at angles, the cushions and the backs should have a combination of convex curves, as, for example, in Fig. 7. Recently, I sat in a wonderful piece of furniture made in England. It had a curved cushion and a curved back which fitted my body perfectly. If a car seat is made more like the human form it will not be necessary to make it so soft. An idea seems to be prevalent that the cushion and the back of a seat should be made real soft; but it does not follow that mere softness will give a passenger a comfortable ride. The real test is, how he feels after he has ridden several hundred miles in it. In my experience, a seat that is fairly rigid is much more comfortable than a very soft one. Experiments could be made by using seats and backs of plastic clay, having men and women sit in such seats and taking impressions of their forms for purposes of seat designing.

It will also be necessary to find new and novel materials for the interiors of bodies. Good inside appearance helps wonderfully to sell cars, and more attention should be paid to it. Snake skins and lizard skins are now being used in Europe to upholster bodies, and a number of body builders in America are experimenting with them. The skins are very durable and attractive.

Convertible Bodies Coming

A tendency toward convertible bodies is evident. People like to live out-of-doors nowadays; consequently, a closed body that can be opened will attract many purchasers. I am not very strongly in favor of a convertible body that is very long. The trend will be toward the more compact smaller types, which can carry four or five or even six persons.

The convertible body shown in Fig. 4 was built for me last summer. The idea was to provide all the advantages of an ordinary two or three-passenger convertible-coupé, with the added advantage of being able to carry two or even three extra passengers in close proximity to those on the front seat, under cover of the roof instead of being outside in an unprotected rumble seat. The rumble seat is an outgrowth of the rumble seat used on carriages. It was a servant's seat. The owner could not with propriety ask a guest to ride there, and it seems inhospitable for an owner of an automobile to ask his guests to ride outside at the rear in an unprotected seat, especially at the high speed traveled by cars today. It is a seat exceedingly difficult to get into and out of, and I think it can never be made really comfortable.

This convertible coupé has a door 39 in. wide, which makes possible the use of a comparatively small collapsible rear-quarter. The body is cut very low behind the door so that the top can fold compactly and naturally. In any convertible body, the shorter it is the fewer movable parts it will have, and this is desirable. The inside of the body is also very wide, 49 in. across the top of the front cushion. The front seat is divided, and both are of the sliding type and have tilting lazy-backs. Two folding seats are in the rear. As the combined width of the two front seats is 49 in., three people can be carried very comfortably in the front and two on the folding seats in the rear. I have carried six in the car. The windshield is 48 in. wide in the clear.

The door is not wide simply because I wanted a large door. I would rather have made it smaller; but, when driving an ordinary two-passenger coupé, if the driver turns to the left to look out he looks right at a blank wall. In time he becomes accustomed to avoiding that and looks ahead through the window. But the 39-in. door has a pane of glass 27 in. wide, which provides better visibility and greater safety. When the top is down the wide glass extends back of the driver and gives much better protection than he would have otherwise.

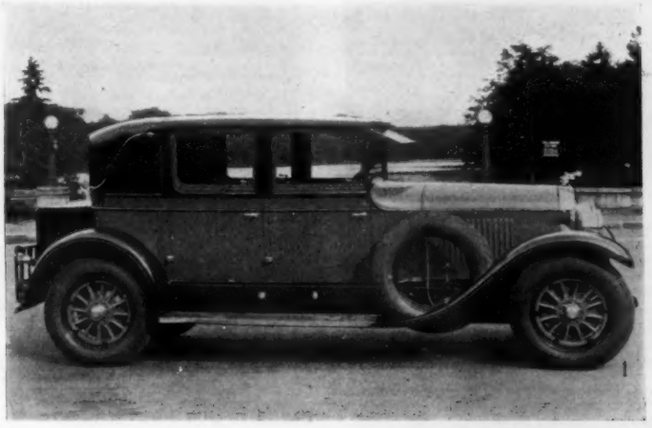
The top folds very easily. I have put the top down all alone in less than 60 sec., and have put it up in half

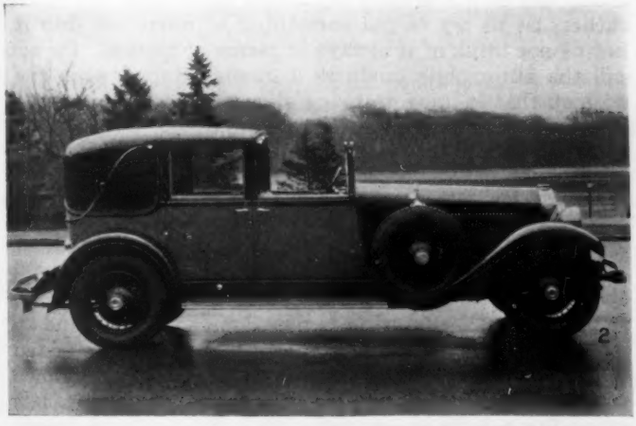
that time. It is only 61 in. in length, from the windshield to the end. The car has a chummy, companionable effect when the passengers are in it. They are close together instead of some sitting in the rear in an unprotected seat.

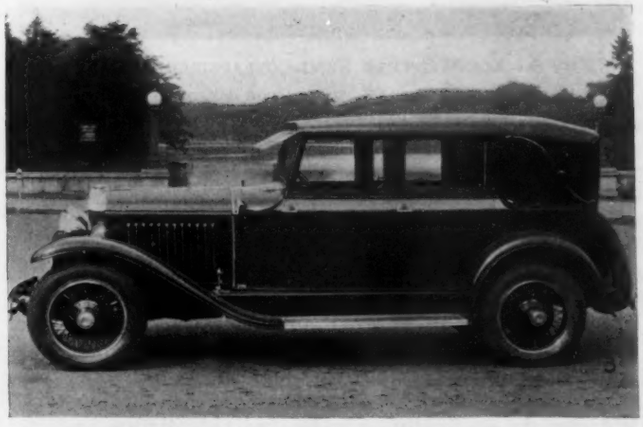
The fact that we made this collapsible top successfully shows that, no matter how difficult it is to make a top for any other sort of body, it can be done to satisfy public demand. I believe that body engineers can solve this problem of the convertible body and solve it successfully. In the car described, we have supplied a trunk and suitcase rack instead of the usual turtle deck in the rear; but the rear can be made in the conventional manner.

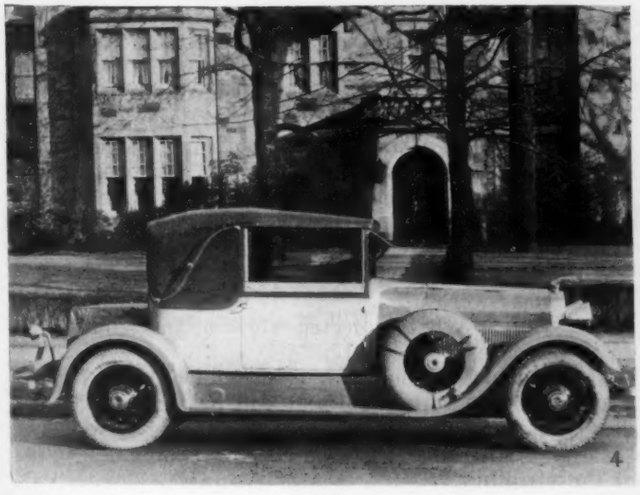
Let us cherish our art above all others and strive to raise its standard higher than ever before. Let us try to do our work so well that those who come after us will find it difficult to excel our achievements. For hundreds of years in European civilization, coach building was regarded as one of the highest forms of art. The coach was an outward indication of wealth and aristocracy. The finest artisans of the period were engaged in this industry, sometimes spending several years in building a single coach. The lines in these coaches were beautiful. In Holland there are carriages on the panels of which Rembrandt painted pictures. Up to the middle of the nineteenth century coach building flourished; but, with the coming of the steam railroads, conditions changed and its decadence began.

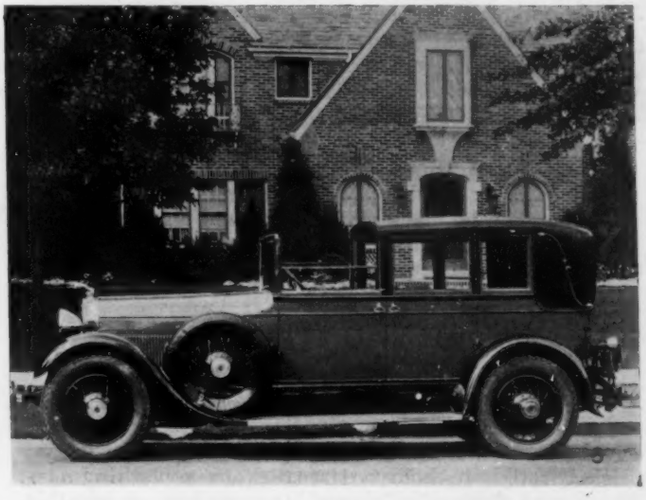
A few years ago another revolution in transporta-











RECENT STYLES IN BODY DESIGN

FIG. 1—FIVE-PASSENGER SEDAN

FIG. 2—ALL-WEATHER SEMI-COLLAPSIBLE CABRIOLET

FIG. 3—FIVE-PASSENGER SEDAN-LANDAULET

FIG. 4—SPORT CONVERTIBLE-PHAETON

FIG. 5—ALL-WEATHER TOWN BROUGHAM

tion occurred with the coming of the trackless automobile. For the first few years the great problem was to make it go; now it seems to be our job to make it beautiful. Let us not always try to get something out of it; rather, let us try to put something of ourselves into it. Let us not think of it always in terms of money. Do not call the automobile business a game. Suppose we try, with all that is in us, to bring about a permanent revival of the centuries-old art of coach building.

FIG. 6—ALL-WEATHER SEMI-COLLAPSIBLE CABRIOLET

The Clean-Looking Rear Affords a Good Example of Hiding the Anatomy of a Chassis by Careful Designing. The View Represents the Rear of the Car Shown in Fig. 2

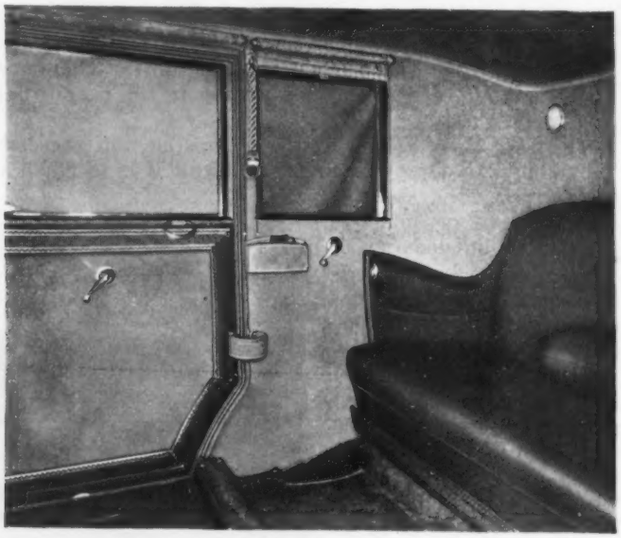


FIG. 7—REAR SEAT OF THE ALL-WEATHER TOWN BROUGHAM SHOWN IN FIG. 5

THE DISCUSSION

CHAIRMAN WILLIAM N. DAVIS[2]:—I am in accord with Mr. Brunn's views on the trends of body design. We are all working to improve automobile bodies and are searching for the formula by which we can make our work live through tomorrow, and through tomorrow's tomorrow, as have the creations of the old masters. We can do so finally only by individualizing and by progressing from year to year until we produce the most comfortable, most practical, and most beautiful bodies our ingenuity can devise. And the trend of design, as I see it, is toward just that.

QUESTION:—Can collapsible bodies be made silent and leak-proof?

HERMANN A. BRUNN:—Yes, but not so easily as a body having a rigid top. The short collapsible body I described can be made rattle-proof and leak-proof. We have done it, and so have others.

QUESTION:—How would you improve the appearance of the rear of an automobile?

MR. BRUNN:—I would install a guard connecting the side-members of the frame and eliminate everything possible to make the appearance neat and clean. The front of many cars is beautifully and smoothly made, but no attention has been given to cleaning up the rear. For instance, a long spout with an ugly cap on it may stick through to hold a tire rack or something else. The guard I mention should drop as low as possible. The lower it is, the closer it will appear to be to the ground. Viewed from the rear, a car without a guard looks very light-waisted.

QUESTION:—Will the fabric body supersede the metal body?

MR. BRUNN:—Painting is now done so quickly and so well with pyroxylin enamels, and repairs can be effected so quickly, that I think the fabric body has no chance with the American public. Another reason is that, supposing a body is covered with a light-colored fabric and delivered now, and that a year from now an accident necessitates a repair, it may not be possible to buy a piece of that same fabric. Even if the piece were cut from the same goods, the repaired part would not look like the rest of the body.

QUESTION:—Is a transparent roof practicable?

MR. BRUNN:—I have seen them in Europe. Glass must be used elsewhere in the car and I know of no objection to using glass in the roof if it is desired. I believe, however, that it would have no very extensive use in America. It would add to the danger unless safety glass were used.

QUESTION:—What projected width of the front pillar do you believe is practical?

MR. BRUNN:—If the pillar is made of brass or bronze it can be made very small and still be strong, and the door pillars can be made very small. We have made some pillars of brass that obstruct probably only ¾ in. of the visibility.

QUESTION:—Do you not believe that all bodies of the future will have curved or concave windshields?

MR. BRUNN:—No. Designs change, and they could not be changed so frequently with a vertically or horizontally curved windshield.

[2] M.S.A.E.—Body engineer, Cadillac Motor Car Co., Detroit.

Space Available for the Body

QUESTION:—What changes in allocation of chassis parts would be most conducive to increasing comfort and to securing better appearance?

MR. BRUNN:—I do not care so much about changes in the allocation of parts on the chassis, provided there is distance enough from the steering-wheel to the rear. It is not the wheelbase that enters into a body-builder's problems so much. One car may have a 145-in. wheelbase on which one cannot build so good a body as on another chassis that has only a 136-in. wheelbase, because so much of the chassis of the former is occupied by the powerplant and steering-wheel that little space is left for the body. We generally begin to design from the steering-wheel and work back. If we have not enough length from the steering-wheel it makes no difference what the wheelbase is or how long the front is.

The pedals should be as close to the floor as it is possible to operate them successfully. On some cars in which the pedals projected so far into the car that the driver was cramped, we shortened the pedals. Most cars now have adjustable pedals.

QUESTION:—Will sheet glass replace plate glass on account of economy?

MR. BRUNN:—No. I think safety glass will be universally adopted.

QUESTION:—Do you think quality design should include new style-features annually, or more often, to accelerate car sales?

MR. BRUNN:—I think they should be changed, but perhaps not annually. It would be advisable to change a poor design right away. Every builder of bodies must be continually injecting new thoughts and ideas into his design, and he must not wait until it has exhausted its usefulness. Good design, or anything else that is well done, is not done quickly. It results from earnest, faithful, painstaking effort rather than from trying to get something out quickly by merely waving a wand. One ought to keep right on working on a good design, and also work on a new one. With the present design on the board, look at it day after day and week after week and see where you can improve its weak points. No designs are so good that they cannot be improved.

Associations

WHILE traditional government tends to break down in the complexity of modern life, new forms are developing which put control into the hands of responsible and self-respecting men. Important among these are professional and trade associations. Almost every field now has its organization, with standards of practice determined by the more representative members. These associations do more than government compulsion to raise standards. They are promising expressions of self-government.

In earlier times men might judge accurately the quality of the simple services and goods they required. Today we often lack time to investigate character, or skill to judge specialized goods or services. We sometimes see big reputations built more quickly by widespread publicity than upon excellent quality. Government cannot protect us from exploitation, except in extreme cases. Here and there the law may bring stragglers into line, as did the pure-food laws; but unless there are organized forces to sustain right motive, government becomes helpless.

Professional and trade associations are providing such forces. Men keenly desire the respect of their peers. The influence of standards voluntarily set by associates is a powerful force for the discipline of human conduct. That influence, rather than legal compulsion, sustains professional and business morals. A calling seldom develops high standards through individual action. Only where men unite to set standards for themselves do honor and pride of workmanship generally control. The exchange of opinion and experience which goes on in such associations is a great force for improving service.

Professional and trade associations have not universally achieved standards that promote the general welfare or represent fair play. In many callings there is need for bringing standards of practice into harmony with general public interest. The code of ethics of any professional or other association expresses the desire to make the standards of conduct in that calling deserve the approval of all self-respecting men. Professional training alone is not enough. Before one becomes a professional man, craftsman, or merchant, he needs to fix his deeper roots and more controlling loyalties in the all-inclusive profession of man.—*Antioch Notes.*

Foreign Trade

THE remarkable expansion in the foreign trade of this Country in the last 15 years is indicated by the fact that both exports and imports in 1927 were more than twice as large, in point of value, as in 1913. Probably less than half of the gain during this period is due to the change in price levels.

In a comparison of increases in our export trade with the different parts of the world, it is significant that the greatest expansion has occurred in shipments to those countries that formerly entered into our foreign commerce in a comparatively unimportant degree. Our exports to Asia in 1926 were 366 per cent larger than the average for 1910 to 1914, while during the same period shipments to Oceania have increased 346 per cent, to Africa 310 per cent, to South America 267 per cent, to other North American countries 135 per cent, and to Europe only 71 per cent. These changes reflect, first, the economic development of the various countries; second, the influence of larger American investments abroad, especially those for productive purposes; and, third, the increasing significance of advantages due to climate, natural resources, and the like as a basis for the interchange of commodities.—*Guaranty Survey.*

The Headlighting Situation in California

To what extent does the use of mechanically defective head-lamp equipment complicate the problem of providing satisfactory illumination for night driving? The accompanying article contributes an interesting collection of facts to the discussion of this question. The data relate to conditions in California and were compiled by Lawrence O'Donnell, Erskine Fellow, University of California, under the direction of L. M. K. Boelter.[1]

Head-lamp conditions, accidents attributable to faulty headlighting, defects in head-lamps, and the effectiveness of headlighting enforcement are the topics covered.

TO afford a better appreciation of the effect of headlight legislation upon conditions on California highways and city streets, the following tabular data are presented, most of which are self-explanatory.

The data incorporated in Table 1 were collected on Sunset Boulevard, Los Angeles; Geary Street, San Francisco; and East 12th Street, Oakland.

Lamp glare was determined by visual observation. In the case of headlight raids, several observers were used and the results of doubtful cases checked by observing the amount of light above the level of the head-lamp centers on a 25-ft. screen.

No photometric checks were made, but the effect on the observers' eyes was considered a reasonable criterion of excessive light causing discomfort to the on-coming drivers. The results given are therefore not "absolute" but may serve as a basis of comparison.

TABLE 1—CITY HEADLIGHTING CONDITIONS

	Los Angeles	San Francisco	Oakland
Total cars registered	630	2,606	1,988
One head-lamp out, per cent	3.43	2.70	3.33
Two head-lamps out, per cent	0.34	0.36	0.22
Glare, per cent	73.80	67.14	72.15
Insufficient illumination, per cent	8.92	8.00	16.00
Satisfactory, per cent	13.5	21.8	8.3

It can be seen that approximately 70 per cent of the head-lamps glared and that 10 per cent gave insufficient illumination, the latter condition causing the lights of an approaching vehicle to appear even more glaring.

Variation with Hour and Weather

Approximately 3 per cent of all cars in the cities are driven with one head-lamp out, and 0.3 per cent with both head-lamps out, as compared with 4.5 per cent with one lamp out and 0.5 per cent with both lamps out on suburban highways.

The chart in Fig. 1 shows the variation of "one head-lamp out" with the time of the evening. The curve shape is difficult to explain but is probably due to the greater number of older cars found on the streets during the periods of maximum lamps out.

The chart in Fig. 2 pictures the variation of "one head-lamp out" with the time of the evening during several rainy periods. The percentage of head-lamps out is doubled as compared with a dry evening, thus showing the effect of defective wiring and electrical connections.

Fatal Accidents from Faulty Headlighting

Locally the only reliable sources of information fixing responsibility for accidents were coroners' reports.

The chart in Fig. 3 shows the fraction of fatalities in Alameda County during 1926 that were directly attributable to insufficient illumination and glare as 5.8 per cent. In addition, insufficient illumination and glare served as a secondary cause in 4.8 per cent of the fatalities. Although the population of Alameda County is concentrated in the East Bay Cities (Oakland, Berkeley, and similar localities), 26 per cent of all fatal accidents occurred on the highway and 39 per cent occurred at night.

The lack of reliable information on the causes of automobile accidents in general cannot be overemphasized, and a remedy should be sought.

Table 2 and the chart in Fig. 4 show the registration, accidents, glare, and one head-lamp out, in percentages for 14 representative cars subject to the conditions stated below the table.

TABLE 2—OAKLAND AUTOMOBILE STATISTICS

Make of Car[1]	Car Registrations, Per Cent[2]	Accidents, Per Cent[3]	Glare, Per Cent[4]	One Head-Lamp Out, Per Cent[5]
A	24.7	25.3	25.6	31.43
B	16.5	16.3	8.54	17.6
C	8.02	7.65	6.00	1.76
D	6.6	7.25	10.3	8.78
E	5.8	5.54	4.27	0.88
F	3.73	3.89	5.12	5.26
G	2.82	2.77	0.85	1.76
H	2.62	3.47	3.42	1.76
I	2.29	2.18	8.54	9.65
J	2.26	2.30	5.12	0.88
K	1.67	0.59	0.85	0.00
L	1.57	1.71	0.85	0.88
M	1.57	1.47	1.71	1.76
N	0.27	0.18	0.00	0.00
All others	19.58	19.40	18.83	17.60

[1] (A, Ford; B, Chevrolet; C, Buick; D, Dodge; E, Studebaker; F, Star; G, Overland; H, Hudson; I, Essex; J, Nash; K, Packard; L, Cadillac; M, Willys-Knight; N, Lincoln).

[2] Percentage of each make of car of total registration, in Oakland, taken from Division of Motor Vehicles, State of California, 1926.

[3] Percentage of each make of car of total cars involved in accidents, taken from figures of East Bay Safety Council, covering accidents for the first six months of 1926.

[4] Percentage of each make of car of total cars (117), with glaring head-lamps, from Oakland Headlight Raid, Jan. 8, 1927.

[5] Percentage of each make of car of total cars (3532), with one head-lamp out, from a count on East 12th Street, Oakland, on three nights during January, 1927.

The slopes upward from right to left of the blocks in Fig. 4 show that the greater head-lamp difficulties occur with lower-priced cars, thus indicating that there is a direct relation between the cost of the head-lamp equipment (and car) and headlight enforcement difficulties.

Defects in Head-Lamps Classified

In Table 3 may be found in percentages the difficulties encountered with head-lamps on 125 representative cars, the data having been collected in six official State adjusting

[1] M.S.A.E.—Instructor, automotive construction, University of California, Berkeley, Cal.

stations. Of these defects, poor electrical contacts and connections, and incorrectly designed and poorly constructed sockets and focusing mechanisms head the list; but all may

TABLE 3—HEAD-LAMP DEFECTS NOTED BY GARAGES

	Number of Cars	Percentage of Cars
Socket Defect		
Weak plunger	4	3.06
Socket stuck	1	.76
Bad socket	9	6.87
Socket improperly inserted	1	.76
Total	15	11.45
Poor Connections		
Battery	4	3.06
Socket	2	1.53
Ground	4	3.06
Switch	4	3.06
Rust around reflector, ground broken	4	3.06
Total	18	13.77
Lens		
Broken	2	1.53
Illegal	4	3.06
Twisted	3	2.29
Loose, poor clamps	3	2.29
Total	12	9.17
Out of Adjustment	26	19.78
Gasket Broken	2	1.53
Beam Control		
Bracket adjustment necessary	6	4.58
Bracket bent, not S.A.E.	10	7.64
Total	16	12.22
Lamp Smashed, Due to Collision	4	3.06
Head-Lamp Electric Incandescent Lamp		
32-Candlepower	3	2.29
Burnt out	19	14.51
Total	22	16.80
Focusing Screw Stripped	2	1.53
Reflectors		
Upside down	1	.76
Loose	3	2.29
Bent	1	.76
Total	5	3.81
Poor Wiring	3	2.29
Battery Trouble	4	3.06
Circuit-Breaker Stuck	2	1.53
Grand Total	131	100.00

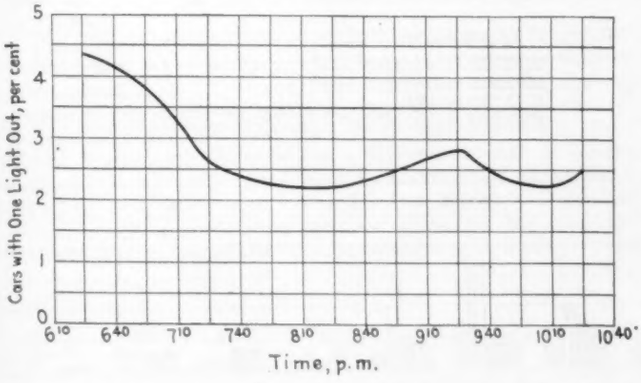


FIG. 1—VARIATION IN HEAD-LAMP CONDITIONS WITH TIME OF EVENING

The Chart Indicates, Roughly, that the Percentage of Cars with One Head-lamp Out Decreases with the Lateness of the Hour. An Explanation Offered Is that a Greater Number of Old and Hence Defectively Equipped Cars Are on the Streets Earlier

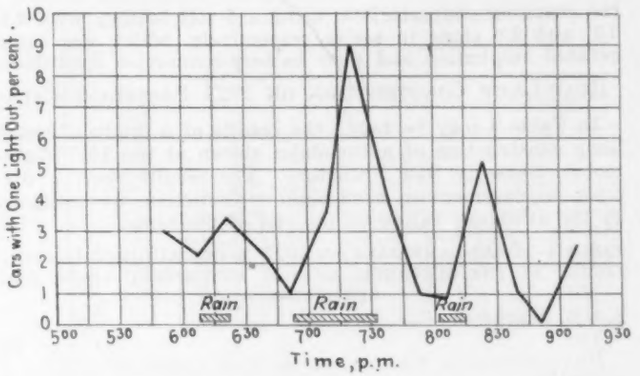


FIG. 2—VARIATION IN HEAD-LAMP CONDITIONS DURING RAINY PERIODS

Observations of 1600 Cars Form the Basis of This Chart. The Greater Percentage with Lamps Out as Compared with a Dry Evening, about Double, Shows the Effect of Defective Wiring and Electrical Connections

be reduced by more liberal design. The item 19.78 per cent "out of adjustment" also is largely made up of socket and focusing-mechanism defects.

VOLTAGE AT THE LAMPS

A very important factor usually causing insufficient illumination is the voltage at the lamp. The drop of potential due to the increased circuit resistance with age,

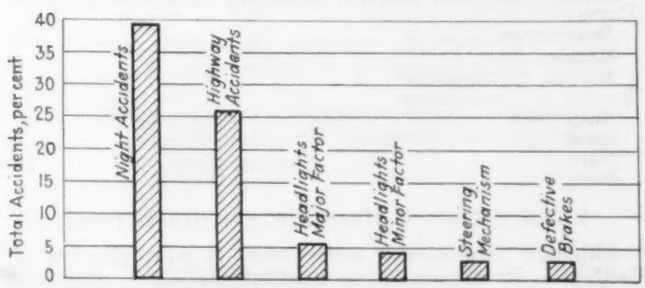


FIG. 3—CAUSES OF FATAL ACCIDENTS

Coroners' Reports Were Consulted for this Analysis. The Chart Indicates that More Than 10 Per Cent of All the Fatal Accidents Were Directly or Indirectly Due to Faulty Head-Lamps

and the corresponding poor contacts, has been discussed at length in other papers. However, one characteristic of the third-brush generator, with which most cars are equipped, that of charging a partly discharged battery (low back e.m.f.) at a lesser rate than a fully discharged battery (high back e.m.f.) accounts for a great number of cases of low voltage at the lamps.

The curves in Fig. 5 show the characteristics of a typical constant-potential vibrating-resistance and third-brush generator. The curves in the upper half of the figure show that the vibrating-resistance generator regulation will tend to charge a partly discharged battery at a greater rate, thus automatically maintaining the battery at or near full charge.

This is not true of the third-brush generator at a higher speed than 900 r.p.m., and the addition of a great number of accessories requiring energy from the battery has contributed to the low-voltage condition at the head-lamps. Of course this condition can be remedied by readjusting the position of the third brush, but this is not always done by the owner or repair man. A low-gravity battery condition leads to a "sulphated" battery. Poor battery-connections or a sulphated battery change the third-brush characteristics as shown in the lower portion of the chart in Fig. 5. The two sets of curves for both generators illustrate

the charging characteristic using a 6-volt battery with 0.1, 0.5, and 2.0 ohms in series respectively, which are exaggerated sulphation and poor battery-connection conditions.

Head-Lamp Construction on 1927 Passenger-Cars

In Table 4 may be found the results of a study of head-lamp construction of automobiles shown at the 1927 Automobile Show in San Francisco. The results show a distinct improvement in head-lamp construction, as indicated by the arbitrary rating at the end of the table.

TABLE 4—HEAD-LAMP DATA ON 1927 MODEL AUTOMOBILES COLLECTED AT THE ELEVENTH ANNUAL AUTOMOBILE SHOW, SAN FRANCISCO

S.A.E. Brackets	
Yes	25
No	6
Similar	4
Lens	
Clear glass with fluted reflector	7
Prismatic, or combination	28
Feeder Wires	
Cable and metal connector	24
Wires and rubber connector	8
Hidden feeder-wires	3
Cross-Rod	
S.A.E. Standard	31
Not S.A.E. Standard	3
No cross-rod	1
Doors	
Bayonet joint	24
Hinged	8
Bayonet joint with retaining screw	18
Bayonet joint with retaining hook	2
Band	3
Focus	
Rear screw	33
Remove door	1
Bottom thumb-screw	1
Quality of Head-Lamp	
Very good	12
Good	9
Fair	10
Poor	4

Enforcement of Headlighting Regulations

Although "educational" enforcement is most effective in California, its application to headlighting seems questionable. It was found in one headlight raid that only one driver out of 43 knew how to adjust his own head-lamps, while few appreciated the fact that their head-lamps were out of adjustment. The chart in Fig. 6 indicates the frequency of adjustment of head-lamps. Eighty-seven drivers were questioned during a headlight "raid." The results indicate that the average head-lamp receives only occasional attention from the driver or owner.

During a three-night raid in Oakland, 391 car drivers were given citations, representing 0.38 per cent of the city's 1926 passenger-car registration. Referring to Table 1, it may be inferred that a solution of the problem must result

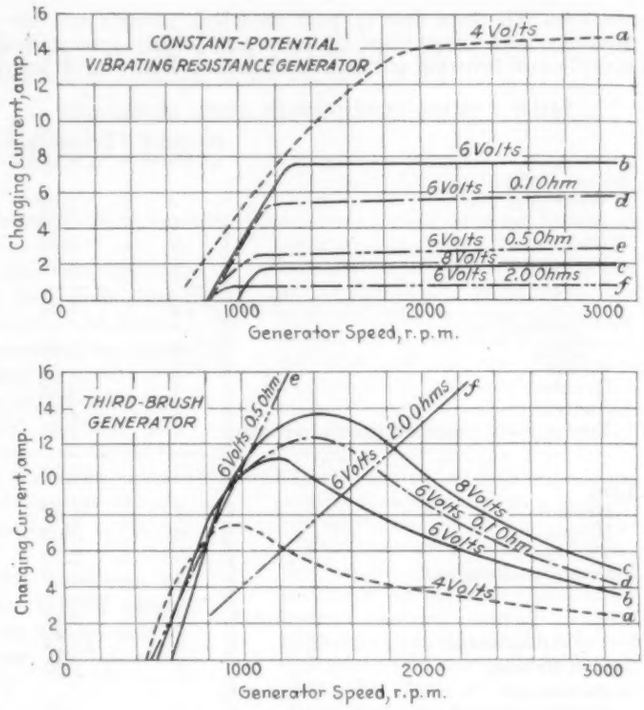


FIG. 5—GENERATOR CHARGING CHARACTERISTICS

The Voltages Indicated on Curves *a*, *b* and *c* Refer to Battery Back Electromotive Force. The Fact that a Third-Brush Generator Charges a Partly Discharged Battery at a Lesser Rate than a Fully Discharged Battery Accounts for Many Cases of Low Voltage at the Lamps; a Vibrating-Resistance Generator, as Can Be Seen from the Curves in the Upper Half of the Figure, Tends to Charge a Partly Discharged Battery at a Greater Rate, thus Maintaining the Battery at or Near Full Charge. Curves *d*, *e* and *f* Represent Exaggerated Sulphation and Poor Battery-Connection Conditions. From These the Extent to Which Such Conditions Affect the Characteristics of Third-Brush Generators Can Be Seen

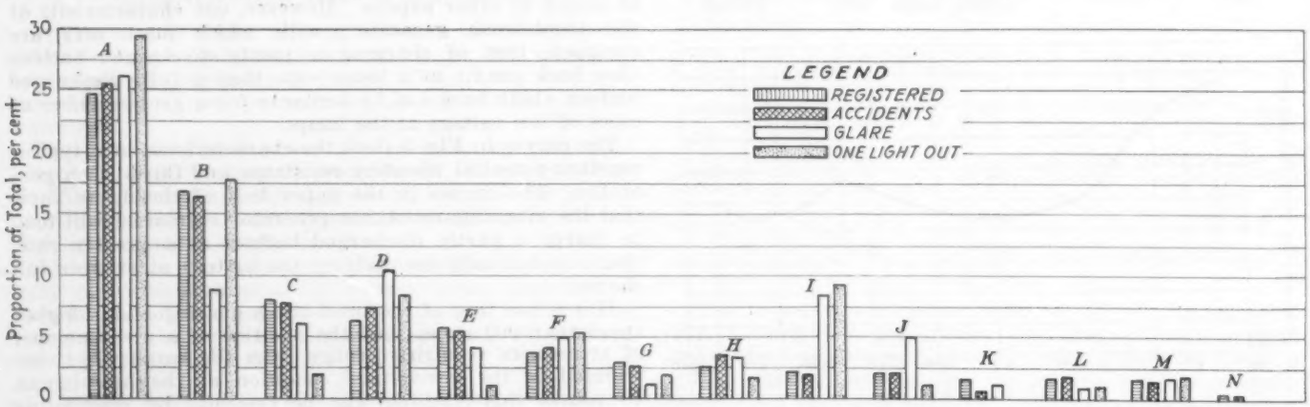


FIG. 4—PERCENTAGE OF TOTAL REGISTRATIONS, ACCIDENTS, GLARE, AND ONE LIGHT OUT FOR VARIOUS MAKES OF CAR

The Accident Statistics Were Taken from Figures Covering Six Months Compiled by the East Bay Safety Council. A Survey of 117 Cars Furnished the Glare Data, and a Count of 3532 Cars, Conducted on Three Separate Nights, Is the Basis for the Conclusion as to the Proportion of Cars Driven with One Light Out. The Slopes Upward from Right to Left Link Increasing Head-Lamp Difficulties with Decreasing Car Prices (A, Ford; B, Chevrolet; C, Buick; D, Dodge; E, Studebaker; F, Star; G, Overland; H, Hudson; I, Essex; J, Nash; K, Packard; L, Cadillac; M, Willys-Knight; N, Lincoln).

from continuous cooperation of the manufacturer, the automobile owner, and the law-enforcement officials, rather than from the citation and arrest of the driver of a car having defective lighting equipment.

Table 5 indicates the promptness displayed by the motorist in complying with the citations issued. The data for the table were determined when the citations were from one to seven days overdue.

TABLE 5—CITATIONS RETURNED TO POLICE DEPARTMENT

Defect Given in Citation	Report Made to Police Department	No Report Made to Police Department
Glaring head-lamps	342	35
Glaring spot-light	4	2
One head-lamp out	43	21
Both head-lamps out	5	1
No tail-lamp	15	4
Illegal lens	3	2
Total cars	345	46
Percentage of Total	88.25	11.75

The effectiveness of a headlight raid may be gaged to a certain extent by examining Table 6, which shows that the percentage of "one lamp out" was decreased slightly but not much.

TABLE 6—COUNT ON 12TH STREET AT 26TH AVENUE, OAKLAND

	Before Raid	After Raid
Number of cars counted	1,044	944
Time	Monday, Jan. 31, 6:15 to 8:25 p. m.	Monday, Feb. 28, 6:15 to 8:25 p. m.
Percentage with one lamp out	3.60	3.42

CONCLUSIONS

(1) A glaring head-lamp is the rule rather than the exception, due almost entirely to defects in mechanical details of head-lamp construction.

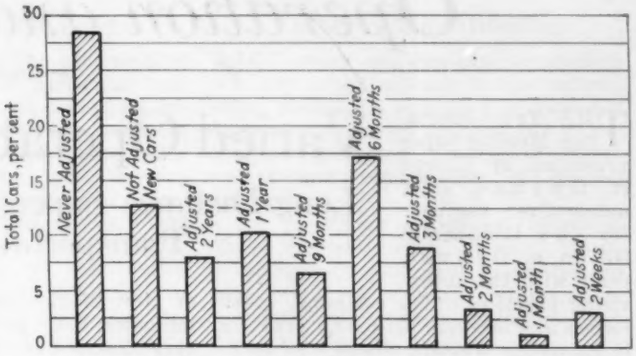


FIG. 6—FREQUENCY OF HEAD-LAMP ADJUSTMENT

Eighty-Seven Drivers Were Questioned During a Headlight Raid. The Answers Summarized in This Chart Indicate That the Average Head-Lamp Receives Only Occasional Attention from the Driver or Owner

(2) The glare problem is directly related to head-lamp (or car) selling price.

(3) Improvements in mechanical construction of head-lamps are noticeable in 1927 models. This improvement should make itself manifest on the highways within a two-year period.

(4) "One head-lamp out" and weather conditions are definitely related, showing the importance of weatherproof electrical connections.

(5) The condition of lack of reliable statistics on causes of accidents requires immediate attention.

(6) The third-brush generator characteristic tends to further reduce the voltage of a low-voltage system.

(7) Headlight raids are effective only in bringing the public to realize its voluntary part in the enforcement program.

Effectiveness of Labor

NEITHER high money wages nor low money wages, neither a high monetary scale nor a low one, count as factors in promoting international trade or in retarding it. Goods move from the dear countries to the cheap countries, from those with high wages and great prosperity to those with low wages and hard conditions, quite as much as the other way.

The effectiveness of labor in the United States is greater than in any other country. It is more than double that of Great Britain or of prewar Prussia, at least thrice that of Belgium, five times as great as that of British India. It is markedly greater than that of the nearest rivals, New South Wales and Nova Scotia. The greater use of power and machinery contributed most to making American labor effective and productive. The United States has greater effectiveness in producing window glass by the machine process, but no superiority in producing by the hand process.

The real reason why Americans are more likely to hold their own where machinery is used much, and where hand labor plays a comparatively small part in the expenses of production, is that Americans make and use machinery better. They turn to labor-saving devices that save more labor. Sometimes the machinery is lower in price than the same machinery made abroad, because made with labor that is more effective. Sometimes it is the same in price, but is utilized better and made to turn out more product per unit of operating force. Sometimes, though dearer in absolute price, it is still cheaper to use, cheaper relatively to its effectiveness. The result is the same whatever the details of the differences. The same product costs less money in the United States than in countries not so adept with the machine process, and the same labor turns out more of the product. The question remains one of comparative effectiveness.—F. W. Taussig, in *International Trade.*

Operation and Maintenance

Varied Operating Conditions

Long-Distance Supervision of Motor-Vehicle Transportation Outlined

THE Transportation Meeting paper presented by George R. Gwynne, chief automotive engineer for the Continental Oil Co. at Denver, dealt with the supervising practices of his company, which refines and markets petroleum products in numerous Western States. To facilitate supervision, the company has established so-called motor-equipment divisions located in large Western cities and has provided a "base shop" at each of these locations. "Sub-base shops" have been established also in isolated parts of the company's territory, and each of these is operated under the direction of the superintendent of the base shop in the division in which it is located. Headquarters for traveling inspectors are also provided in each of the divisions.

Sub-base shops are small but are well equipped with tools to enable them to render major service. They are not equipped, however, for completely rebuilding the vehicles. The personnel of the organization is distributed so that, from a geographic and a railroad-transportation viewpoint, the company is protected in regard to man-power position for virtually any emergency. All motor-equipment-division garage-shop superintendents and personnel are under the direction of the home-office automotive-department, which is located at Denver and is in charge of Mr. Gwynne.

The Continental Divide runs through the company's territory from the Canadian line to the Mexican Border. Fully one-third of the entire area is very mountainous and has also very high altitudes, the highest being 11,500 ft. above sea level. In contrast, the company also serves territory in the deserts of New Mexico and Utah and in the mesquite flats in Texas, these being very destructive of equipment on account of dust of an abrasive character and mesquite thorns. In short, the company operates and maintains its vehicles under nearly every kind of climatic and topographical condition that exists in the United States.

Climatic and topographical conditions alone present an interesting problem with regard to standardization, as it is necessary to use as few makes and models of passenger-car and truck as possible, yet the vehicles must work equally well in the cities, in the desert, in the high mountains and in snow. The standardization of equipment is decided upon only after rigorous tests are conducted by Mr. Gwynne personally over a test course which represents severe road-conditions. In one section the difference in altitude in 10.7 miles is 725 ft.; in another, the drop in altitude in 3.1 miles is 1000 ft. These sections afford splendid opportunities for brake tests. The operating tests on the section having a difference in altitude of 725 ft. are made in high gear at speeds of 25 to 30 m.p.h. Unless the brakes are well designed, generous in proportions as to area, and well cooled, they will not withstand these tests without burning.

The base shops which are located at motor-equipment division headquarters are equipped with standard power-tools and minor equipment-repair facilities. Plenty of natural light is provided, and cleanliness is insisted upon. The requirement of cleanliness is extended to include even the personnel, and shower baths for the men are provided.

As an example of the difficulty of maintenance and operation due to the great distances which separate the various stations of the company, one sub-base shop is 102 miles from the nearest standard-gage railroad and 277 miles from the company's supply of replacement parts. The accompanying illustrations indicate the operating difficulties due to terrain and to climatic conditions on the desert near Shiprock, N. M.

With regard to repair work, the job orders are written when the physical inspection of the vehicle is made and are mailed to the home-office automo-

tive-department. There they are checked. The work of all service jobs is started by the inspector at once. He enters the expense for labor and material on forms. One of the forms is mailed to division headquarters for accounting and for production checking, and one is mailed direct to the home-office automotive-department. Expense is accumulated on a printed form, the data then being posted to another form in the general office which constitutes the unit control. The overhead costs are then picked out, distributed and posted.

Interesting Cost Data

Mr. Gwynne stated the accumulated costs of operating one particular unit of automotive equipment during its entire life. He said $2,168 was spent for gasoline, $2,836 for tires, $3,837 for repairs, and $681 for miscellaneous items, a total of $9,522. Drivers' wages were $8,838; depreciation, $2,275. From the total of $20,635 was deducted $650, the turn-in valuation of the vehicle, which leaves an expense of $19,985 for operating a unit that originally cost $2,275. It ran a total of 99,658 miles.

Valve Reconditioning

NOT many engines can accumulate any great mileage in use without valve trouble, as evidenced by repeated demands on service stations for valve-tappet adjustment, freeing of sticky valves and replacement of burned valves.

An important paper on Scientific Valve Reconditioning, by Jack Frost, is printed in this issue beginning on page 644, and members interested in uptodate maintenance practice are urged to read it.

Nine Technical Sessions Scheduled

(*Continued from p.* 620)

spark plug, so as to enable an engine to be indicated by removing the spark-plug and substituting the new unit.

Poppet-Valve-Spring Design

A. Moorhouse and W. R. Griswold

Development of the Packard dual valve-spring is the result of a study of valve-spring breakage, which divides naturally into two phases. The first phase, that of stress and the fatigue of metal subjected to repeated stress-changes, was studied first. An effort was made to determine stress ranges of a normal character within which repeated stress-changes could be applied without premature breakage. Abnormal stresses were then studied with the purpose of eliminating the abnormal or secondary stresses, which are primarily the result of resonant vibrations in the spring itself.

The nature of resonant vibrations was studied by stroboscopic observation, using the systematic process of elimination by studying the effect of one variable at a time. Various theories of resonance were investigated for the purpose of determining why some critical vibrations were more severe than others. The relation of stress range, valve lift, natural frequency of vibration, rate of action, and weight of the spring was formulated.

This relationship indicated that generally, but particularly under certain circumstances such as limited space and high valve lifts, a single spring had definite limitations which could be overcome by the use of multiple springs of identical characteristics instead of a single spring meeting the same maximum-load requirements.

Multiple springs seemed at first to involve design and manufacturing difficulties that required careful study. Only two choices seemed open: (a) to arrange a group of two or more small coil springs in an annulus about the valve-stem and provide a rather expensive cage and seat combination for holding the springs in place, which had the disadvantage of requiring more space than was often available, and (b) to wind the springs like double or triple-threaded screws and fasten the spring ends in a suitable retainer or seat. The latter course was the more practicable and has worked out well in production. The design of the retainers and the production methods are described and illustrated.

The second phase of the investigation pertained to materials and their fatigue properties, more particularly with reference to uniformity of life under test than to the relationship of stress to life. Some phases of testing materials which are regarded as an index to the life of the finished spring are mentioned. Some data on tests of many sets of valve-springs are also given.

Other advantages as regards valve noise, valve-guide wear and general preservation of the valve gear by the elimination of valve clatter are discussed.

Methods of Obtaining Greater Power From Engines

Thomas J. Litle, Jr.

Because of the insistent demand for more power from our passenger-car engines, every producer is faced with the problem either of designing new powerplants or revamping his present designs to obtain more power. In this paper an endeavor is made to show many possibilities of obtaining more power from a given engine.

The information has been obtained experimentally in most cases and is the result of experience gained in revamping several powerplants. As most engines are not perfectly designed, such power increases are actually obtainable.

It may be said that every engine on the American market today, no matter how well designed, could be improved by very careful and painstaking experimental research. Most manufacturers have been working along these lines during the last year, and certain fundamental changes, which would increase the power of any engine, can be grouped under the following headings: (a) increasing the speed; (b) increasing the volumetric efficiency; (c) increasing the compression ratio; (c) increasing the thermal efficiency; (e) increasing the mechanical efficiency.

In the paper these headings are subdivided and discussed separately. The author has gone so far as to suggest that it may be possible to supercharge certain existing engines without greatly changing their present design.

A comparison is made of engine performance as based on the number of cubic inches displacement per horsepower as the most correct method in comparing engine performance in respect to fuel consumption. The author points out that, when comparing engine performance with respect to car performance, a more accurate comparison would be engine weight per horsepower.

The Angular Distortion Of Crankshafts

C. A. Norman and K. W. Stinson

To compute the critical speed of a given crankshaft it is necessary to know how much its various parts are distorted by given torques. While a great deal has been written and several methods have been published for finding the critical speed once the angular distortion is known, it is rather strange, state the authors, that our knowledge of the angular distortions of various types of crank arms seems to rest upon a very scanty basis of published experimental data. Such data as there are do not seem to agree well with one another, and arms running from crank-pin to crankpin rather than from a journal to a crankpin, seem to be very scantily covered, if at all. Theoretical formulas covering the subject are very complicated, but are not certain.

To clear up this matter, a six-cylinder Continental engine and five crankshafts were donated to the engineering experiment station of the Ohio State University. Three of these crankshafts were planed down so as to present a series of arms with decreasing thickness and width. The distortions of these arms were determined optically with a telescope and tilting mirrors. It was found that the measured distortions could be represented by very simple curves, in fact, by straight lines, when plotted against the reciprocals of the moments of inertia of the arm sections. In consequence, it was found possible to develop a very simple rational, or semi-rational, formula whereby the angular distortions of the arms can be computed from the dimensions. These formulas and the original experimental data, are the subject of the paper to be presented before the Society and of Bulletin No. 43 of the Engineering Experiment Station, Ohio State University.

TRANSMISSION SESSION

The Sensaud de Lavaud Automatic Transmission

D. Sensaud de Lavaud

Mentioning the various attempts that have been made to secure continuous progressive changes of gear in the automobile, the au-

thor states that nothing of this sort is of value unless it is automatic.

He has designed a transmission consisting of a wabble plate which actuates six connecting-rods that operate as many roller clutches on the rear axle. Changes in speed result from variance in the inclination of the wabble plate, and this is controlled automatically through the combined effects of inertia and the reaction of the resistance.

This transmission has been applied to a number of cars of different weights, some of which have seen much service. The action of the various elements of the transmission is analyzed with the aid of drawings, diagrams and formulas, and the proportions are stated that have been found most successful. This transmission is combined with a gearless differential and a planetary reverse gear.

Front-Wheel Drives; Are They Coming or Going?

HERBERT CHASE

This form of drive is reported to have been in actual use as long ago as 1862 and was applied to gasoline-driven vehicles during the first five years of this century if not before that date. Therefore, this paper is, in part, a review of information culled from the automotive literature, but it includes a record of certain recent designs, some of which probably are new to most members of the Society. There is also an analysis of the advantages and disadvantages of front-wheel drives in general which, it is hoped, will provide a useful background for those who contemplate a further study of the subject.

The author's comments apply especially to passenger-cars but they apply also in many instances to truck and motorcoach chassis. One of the few original American designs shown has been applied in practice only to motorcoach chassis but seems to be adaptable to other passenger vehicles and to trucks as well.

The author acknowledges indebtedness to many engineers, including several of the most prominent in the industry, for comments some of which are quoted verbatim and others used less directly in the text.

BODY-DESIGN SESSION

Appeal of the Motor-Car to Women

PAUL THOMAS

The word "fashion" is much discussed today and the terms "art in industry" and "art in trades" are bandied about freely, but there is much confusion in the use of these terms, which mean one thing to this man and something entirely different to that man. Everyone is stirred up about using color on his products, but few have a clear idea of when to use color, how much to use, or what colors to use. A manufacturer proudly shows the newest model of his product and says it is a modern design, but he cannot defend it against criticism or explain just where it fits into the scheme of things today.

An increasing army of manufacturers and merchants realize that their merchandise must be sold on a plus appeal called "style" or "fashion" and that the public demands more than that the product be mechanically perfect or practical and useful.

In creating and merchandising dress silks, Cheney Brothers have found some of the underlying principles of fashion. These can be translated freely into terms of the automobile business, because they apply to automobiles exactly as they do to dress silks.

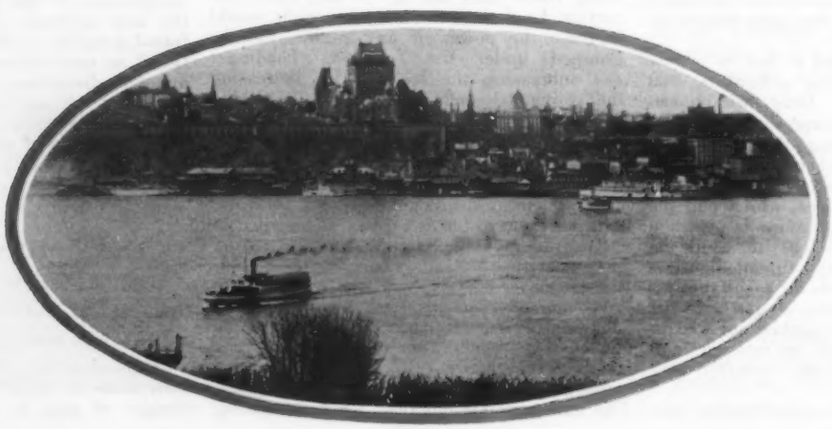
The automobile must be an object that delights the eye, fills the purchaser with the pride of ownership, gratifies the desire for luxury and gives an impression of power, speed and graceful flight. But we occasionally see distressing examples of design that are created because the designer has not recognized the limitations of his problem.

One of our outstanding faults today, even in the finest cars, is the habit of hanging gadgets in every possible place. Having developed the streamline principle in the general outline, we break up the flow of line by putting spare tires on the running-board and surmounting them with gaily nickeled mirrors fastened on with chains.

Simplification is the keynote. Much can be done with fender lines. It may even be possible to hide the lamps or at least make them conform to the lines of the car. Much has been done to simplify the dash; instruments have been grouped into small panels, but we introduce moldings and ornamentation, with the result that the dash is as dizzy as before.

There is much to be done with fabrics by the introduction of new weaves and textures that will add variety and give an individual character to the car interior. The one simple principle is that style and fashion are arrived at by making the design adhere rigidly to the inherent qualities of the object we are designing. It is not necessary to borrow or transplant. There is such a wealth of characteristics to express and interpret that we can go on designing cars endlessly virtually without repetition. Another angle closely related to this is that endless variety is to be obtained by making our cars interpret the personality of the owner. Since more women than men have leisure to drive, we can well make our cars appeal to women by emphasizing grace and harmonious coloring and by a refinement of detail to which women instinctively respond.

It does not require superhuman creative genius to change these things, but simply a straightforward attack of the problem, with an understanding of the result to be obtained. When they are accomplished the result will be "modern art" of the finest sort. We shall attain originality and variety, and the ensemble will appeal subtly to the people who buy motor-cars.



Production Engineering

Tool Standardization

Committee Meeting in Pittsburgh Receives Reports and Makes Appointments

AN extended program for standardization of machine-tools was adopted at a meeting of the Sectional Committee on Small Tools and Machine-Tool Elements that was held in Pittsburgh on May 15 to receive reports from its several technical committees and to consider new projects that have been suggested. The Sectional Committee was organized several years ago under the procedure of the American Engineering Standards Committee and is sponsored jointly by the Society, the American Society of Mechanical Engineers and the National Machine-Tool Builders' Association. The first standard formulated by the Committee that related to machine-tool construction was that for T-Slots, Bolts, Nuts, Tongues and Cutters which was issued last year and published in the January, 1927, issue of THE JOURNAL.

MACHINE TAPERS

Prior to the meeting of the Sectional Committee in Pittsburgh, the Technical Committee on Machine Tapers held a meeting to review information that had been gathered regarding the adoption of a standard and what the standard should be. Replies to questionnaires sent out by the Committee and also from the Society's Standards Department indicated divided opinion as to the use of the present Morse, the Jarno, the 6/10, the ⅝ and the ¾-in. per foot tapers.

The Committee's work on the standardization of tapers relates only to their use in machine-tool construction and is based on the experience with present tapers in various types of tool and the feasibility of discarding them for a relatively new standard taper for all machine-tool applications. The first definite question voted on was whether only one standard series of taper sizes should be adopted, the vote being unanimously favorable to a single standard. The next question submitted was whether the standard should be a compromised series of tapers composed, for instance, of the ½-in. taper for sizes No. 000 to No. 0, the Morse taper for Nos. 1 to 5, and the ¾-in. taper for larger sizes up to possibly 12 in. diameter, as against a new and what might be termed an ideal standard. Extended discussion and a trial ballot indicated an almost even division of opinion and it was finally voted that a special Subcommittee of seven members be appointed to review all data available to the Committee and prepare a definite plan for standardization. This Subcommittee was instructed to have its report ready for presentation at the Machine-Shop Practice Meeting to be held in Cincinnati Sept. 24 to 26. Among those signifying their willingness to serve on the Subcommittee were C. E. Rundorff, of the Buick Motor Co., who had submitted a complete series of tapers up to 12 in. diameter with the 6/10-in. per foot taper, and C. W. Spicer, who is one of the Society's representatives on the Technical Committee on Tapers.

SECTIONAL COMMITTEE MEETING

The meeting of the entire Sectional Committee on Small Tools and Machine-Tool Elements began with a general review of the organizing of the Committee and the program it had undertaken. This was followed by short addresses by E. W. Ely, acting director of the Division of Simplified Practice, Department of Commerce, who attended as Secretary Herbert Hoover's representative, and by M. E. Steczynski, who spoke on the application of the system of preferred series of numbers in machine-tool standardization. The Committee voted that these series of preferred numbers recommended by the A. E. S. C. be considered by the several Technical Committees as the basis for the progression of sizes in machine-tool standardization.

The first proposal on which the Committee acted was the authorization of an Executive Committee to carry on the routine work, which it was felt could be done more quickly and effectively in this way than by the Sectional Committee as a whole. Those named to serve on the Executive Committee are: H. E. Harris, Chairman, also chairman of the Sectional Committee; J. A. Anglada, secretary of the Sectional Committee; F. O. Hoagland; C. W. Machon; and C. W. Spicer. R. S. Burnett, Standards Manager of the Society; E F. DuBrul, general manager of the National Machine Tool Builders' Association; and C. B. Le Page, assistant secretary of the American Society of Mechanical Engineers, were named as ex-officio members representing the sponsors. F. O. Hoagland was elected Vice-Chairman of the Sectional Committee, and J. A. Anglada, who had been Acting Secretary, was elected to hold office permanently. The Committee also decided that only two regular meetings will be held during the year, in the spring and in December. Special meetings may be called when necessary, however.

TECHNICAL COMMITTEE SUBJECTS

The Technical Committee on Tool-Holder Shanks and Tool-Post Openings reported that the proposed standard had been submitted to the members of the Committee for approval and that it would also be submitted soon to the Sectional Committee for ballot. It was indicated that the report is thought to be satisfactory for adoption, and Mr. Burnett reported that the Production Division of the S.A.E. Standards Committee had already recommended its approval in June by the Society as one of the sponsors for the project, so as to avoid the holding of the report until the Annual Meeting of the Society next January for such approval.

It was reported that considerable progress had been made in obtaining information regarding the standardizing of Spindle Noses and Collets. The Executive Committee was authorized to organize a Technical Committee to have a report ready by next September if possible.

Mr. Machon, chairman of the Technical Committee on Milling-Cutters, stated that a definite report probably will be ready for the meeting of the Sectional Committee next December.

In discussing Designations and Working Ranges of Machine-Tools, which is one of the subjects before the Sectional Committee, the existing confusion of capacity designations and the multiplicity of sizes of various types of machine-tool were pointed out. It was felt that these are unnecessary and that prompt action should be taken for the benefit of machine-tool builders and users. However, as the project is complicated by the many types of machine-tool, it was decided that the Technical Committee, when organized, should work through a number of subcommittees, each to be composed of specialists for a general type of tool.

The projects for standardization of Drill Sizes and Drill Bushings were combined because of their close rela-

tion, and a Technical Committee was authorized, on which representatives of the Sectional Committee on the Standardization of Screw-Threads are to be appointed, to cover the requirements for tap-drill sizes.

A Technical Committee was also authorized for Punch and Die-Holder Standardization, with the understanding that this project relates only to blanking and forming presses and not to forging presses.

New Projects

In connection with the suggested standardization of Circular Forming-Tools and Holders, it was stated that no great difficulty is being experienced, as only three or four types are in general use, but that standardization undoubtedly will lead to more complete interchangeability of these tools. The Executive Committee was requested to circularize the extensive users of screw-machines as to the types and sizes of circular forming-tool they now use and what features they would like to have standardized. If replies indicate the desirability of organizing a Technical Committee, this will be done. Another suggested subject was the Mounting of Removable Chuck-Jaws. There is now practically no interchangeability between different makes of chuck. The organizing of a Technical Committee was planned, with the stipulation that its work should relate only to the chuck jaws, and possibly to the spindle mounting-dimensions in the back-plate, but not to the chuck-operating mechanism.

The last and most doubtful project suggested was standardization of Machine-Tool Colors and Paint Materials. It was said that at present machine-tools are painted in a variety of colors, sometimes according to the tool-builder's practice and sometimes to the customer's specification. It was felt that this is expensive, causes many delayed shipments, and tends toward a conglomeration of colors in the machine-tool user's shop. On the other hand, it was stated that this project is not of an engineering nature and therefore is not suitable for the Sectional Committee to take up, as it is primarily a commercial matter; and it was indicated that results would be doubtful, as there seems to be a growing fad for color schemes for machine-tools in different shops that militates against having only one or a very few colors in general use. During the discussion it was asserted that the lacquer-spraying system of painting is rapidly coming into use and that this would overcome to a large extent the added expense and delay in shipment at present caused by special painting by the brush method. It was decided to hold this subject in abeyance for a year.

General

The trend toward machine-tool standardization has been very marked during the last year or two. This is due partly to the increasing desire of machine-tool builders for reduced varieties of tools and reduced cost of production and partly to users' desire for greater interchangeability of machine-tool elements and reduction of stock of tool equipment. There is at present considerable activity on the part of committees of machine-tool builders and committees in various National organizations representing large machine-tool users' interests, such as the Society. The work of these various interests is gradually centering in the general Sectional Committee on Small Tools and Machine-Tool Elements, which is responsible for formulating American Standards for Machine-Tools.

The Production Division of the S.A.E. Standards Committee is taking an active part in this work, both on projects of its own and in cooperation with the Sectional Committee. The General Production Committee of the Society, of which the Production Division is one of the groups, is also interested in promulgating standards in a broad way, as well as in developing activities in other branches of the Society's work in the interest of production engineers. At the meeting of the Sectional Committee, the need for better cooperation and active participation in this work by tool producers and tool users was stressed as necessary to make the work of the Sectional Committee and of other committees engaged in similar activities adequately effective.

Line-Production Layout

IN considering the layout of any section in the works, it will be seen that the principles adopted are, in some respects, departures from ordinary practice. The group system of arranging machines has been definitely abandoned. Even gear-cutting and grinding machines are placed in their correct positions in spite of the difficulties of supervision and the like. On the principle that one man can work three or four gear-shapers, such machines usually form a battery by themselves, but in this case the sequence of operation must be abandoned. Some ingenuity had, therefore, to be exercised in arranging the lines of manufacture close enough together to enable these gear-shapers to be operated in an economical manner. Grinding machines also, irrespective of the difficulties of exhaust fans and conduits, are placed where required in line with the other operations, rather than segregated in a grinding shop. This also is an interesting departure from standard practice, which has been fully warranted by the results obtained. There are, of course, difficulties involved in making separate exhausting arrangements, but the advantages of a progressive layout more than justify the expense entailed thereby.

Economies that result from intelligent remodeling of a section for continuous production, even without the introduction of new methods or machines, are astonishing. In the transmission section, as an example, it was found that the same output could be obtained with the same methods and machines, with one-third less operatives and a corresponding reduction in productive and non-productive costs, provided that the machines were arranged in sequence.

Heat-Treating Impedes Continuity

Enameling ovens, usually installed in an enameling department, are placed in the line of operation wherever required. This necessitates insulation in a number of cases, but, whatever the difficulties, they have been solved with satisfactory results. So far, however, heat-treating processes are the great stumbling-block to the sequence of operations, and the author will not be satisfied until these processes can also be placed in the line of operation. In automobile manufacture, in which practically every piece of steel is subjected at one time or another to heat-treatment, breaking off the sequence of operations because parts have to be despatched to a special hardening shop is one of the greatest drawbacks to continuous production; it is a bottle-neck placed in the line of continuous flow, which in the author's experience provides the most frequent cause for stoppages in production. Furthermore, a much larger stock of parts has to be carried than should be necessary. It is obviously impossible to pass pieces one at a time from shop to shop, and in consequence a stock has first to be accumulated to warrant cartage.

It is true that an overhead chain-conveyor, such as is used in many American plants, could be utilized, but even then the lack of efficient continuous furnaces still acts as a definite block in production. Improvements in electric furnaces are now being made, and it is safe to prophesy that before long continuous furnaces will be placed in the machine-shops themselves, and thus obviate what is now a serious difficulty. For oil-hardening steels a solution of the trouble is already in sight, but the problems connected with case-hardening "in line" are much more difficult to solve.—From a paper read by C. R. F. Engelbach before the Institution of Automobile Engineers, London.

Outboard Engines and Racing Boats

Advance in Two-Cycle High-Speed Engines and Refined Hulls Described at Buffalo by Bruno Beckhard

OUTBOARD motorboats that have come into great prominence of late through races in which they have attained speeds between 30 and 40 m.p.h. were the subject of a most interesting address given by Bruno Beckhard, secretary of the Outboard Motor Contest Board of the American Power Boat Association, at a meeting of the Buffalo Section on May 15 which was attended by about 90 Section members and guests. The speaker's close association with the industry and his wide experience with all types of engine qualified him admirably to give an unbiased review of the subject. His address was concluded with the showing of motion pictures of the Albany-New York City outboard motorboat race that was run during the week of May 14 to 19.

How Engines Have Improved

Discussing the rapid advance being made in motorboat engine and hull design, Mr. Beckhard stated that two-cycle outboard engines are now capable of speeds in excess of 3500 r.p.m. and are effectively controlled by throttling the gasoline-air mixture, whereas formerly only spark control was used. Compression ratios are being increased, with a resultant increase in horsepower and efficiency. The quality of the gasoline used has a decided influence on the engine performance, especially when starting. As the two-cycle engine delivers a power stroke at every revolution, it is difficult, said the speaker, to obtain spark-plugs that will withstand the intense heat.

The engine and the boat must be adapted to each other as to their characteristics if the best speed results are to be obtained, declared Mr. Beckhard, who stated that a point which seems to be little realized is that every hull has an inherent maximum speed, and any attempt to drive it faster than this speed results merely in a waste of engine power, as the propeller simply churns the water without increasing the speed at all or only very little. A given engine and propeller will give the best performance in a hull of a certain shape and size which are best determined by trial. This uncertain factor lends great interest to racing for the motorboat enthusiast.

Rush To See Engine Parts

Although no formal discussion followed Mr. Beckhard's talk because the meeting was a little late in starting and the address held the members interested for about 2½ hr., there was a grand rush to the front of the room when the speaker announced that some outboard engine parts were displayed on the table. Much informal discussion ensued, with many questions put to and answered by Mr. Beckhard.

Chairman William R. Gordon presided. Earl W. Kimball exhibited some lantern slides of Quebec to stimulate interest in the Summer Meeting to be held there June 26 to 29.

At this last monthly meeting of the Section for the season announcement was made of the election of officers for next season, as follows:

Earl W. Kimball, Vacuum Oil Co., chairman; Gustaf Carvelli, Curtiss Aeroplane & Motor Co., vice-chairman; William Edgar John, Buffalo Gasoline Motor Co., treasurer; and Donald S. Cox, Pierce-Arrow Motor Car Co., secretary.

THE JOURNAL is indebted to Mr. Cox for this report of the May 15 meeting, the stenographic report of which was not in hand prior to the closing date for copy for the June issue.

About Garage Equipment

SOUTHERN California Section members and invited guests to the number of more than 300 devoted the last technical meeting of the 1928 season, held in Los Angeles on May 25, to inspection and consideration of modern service-station and garage equipment that has been developed to reduce the cost of motor-vehicle maintenance and repairs. Of particular interest was the holding of the meeting on the tenth

floor of the Frank Wiggins Trade School, where dinner was served after the technical session and the equipment of machines and tools in operation on the first and second floors was inspected. The automotive department of this school is one of the largest in the Country. It contains 60,000 sq. ft. of floor area and is equipped with devices embodying the latest advances in labor-saving machines and tools. This exhibit indicated the extent to which the large-scale operation of motor-vehicles on the Pacific Coast excels that in the territory of other Sections of the Society.

H. A. Campion, principal of the school, told of the facilities the school affords to men in the industry to become skilled in automobile mechanics, and said that tuition is given free.

The Speakers of the Evening

At the technical session R. E. Plimpton, of Chicago; E. C. Wood, of San Francisco and Chairman Ethelbert Favary, of Los Angeles, spoke of the excellent work that is being done by the Operation and Maintenance Committee of the Society. H. L. Horning, of Waukesha, Wis., Past-President of the Society, who was expected to be a guest, telegraphed at the last moment that he could not be present owing to illness in his family.

Regular speakers of the evening were Eustice B. Moore, of the Los Angeles Automotive Works; A. L. Knipping, Jr., of the General Petroleum Corporation; G. F. Grove, of the Weaver Mfg. Co.; M. E. Herwich, of the Hobart Bros. Electric Equipment Co.; C. B. Lindsey, superintendent of automotive equipment of the Los Angeles Railway Co., and A. I. Chamberlain and F. Featherstone, of the Hutton Engineering Co.

Incoming officers and members of the governing board of the Section were announced.

Electric Units Get a Hearing

Cartwright Demonstrates and Explains Constant-Voltage Three-Brush Generator System

About one-third of the time at the last meeting of the season held by the New England Section in Boston on May 9 was taken up by D. C. Cartwright, general service manager of the North East Service Co., of Rochester, N. Y., in demonstrating and explaining the functioning of an electric-generating system for motor-vehicle work, and the remaining two-thirds of the evening was spent in a lively discussion of the subject. These proportions indicate the great interest of vehicle operators in the subject of a good and dependable source of current for starting, ignition and lighting.

The meeting was the last of a series devoted primarily to operation and maintenance, and it brought out an attendance of 225, of whom 55 participated in the members' supper that preceded the technical session. Section business disposed of before launching the main subject of the meeting was the presentation by Treasurer Albert Lodge of the financial report, which showed a substantial gain in cash in the bank during the last fiscal year, and the announcement of officers elected for the coming year. The new officers are: Knox T. Brown, general service manager of the Packard Motor Car Co. of Boston, chairman; George L. Appleyard, partner and service manager in the Robinson-Toohey Co., vice-chairman; Albert Lodge, service engineer of the Charles Street Garage Co., reelected treasurer; and William M. Clark, superintendent of transportation for the S. S. Pierce Co., reelected secretary.

Some lantern slides of Quebec were shown, and the Meetings Manager of the Society, who was a guest of the evening, gave some information regarding the coming Summer Meeting in that ancient Canadian city. Chairman Frank E. H. Johnson presided.

Special Needs of Public Vehicles

After reviewing briefly the development of motor-vehicle lighting from the days of carbide lamps and comparing the conditions of regulating electric-current generation in stationary powerplants and in motor-vehicles, Mr. Cartwright described and demonstrated a generator system developed for use on motorcoaches. On a motor-vehicle, he said, the generator speed ranges from zero to 3000 or 3200 r.p.m. and the temperature from 30 deg. below zero to 100 deg. above zero in the shade. Regulation of the generator on passenger-cars, which is necessary because of the variations in speed, temperature and load, is by the three-brush system. This is simple and regulates the output to suit operating conditions within limits, but this type of generator produces current all the time the engine is running. On taxicabs and motorcoaches, which frequently are in operation 20 to 22 hr. per day, the battery does not require the continuous input of the generator during daylight hours and the generator or battery would be destroyed rapidly, particularly on motorcoaches, for which generators of a capacity of 600 watts are now being supplied.

Charging Voltage Regulated Automatically

The control system finally worked out for these large-capacity generators, said Mr. Cartwright, incorporates constants in the charging system. Voltage of the generator is held constant and the temperature variation is compensated for, thus producing ideal charging characteristics. When the battery charge is low, the generator produces its full output; and as the battery charge increases, the output of the generator automatically decreases. The charging rate is regulated by the difference in potential between the battery and the generator. A cut-out in the lighting system closes automatically when the generator is turning fast enough to develop a higher voltage than that of the battery, and opens when the speed decreases so that the generator voltage is less than the voltage in the battery. Thus the battery charge is conserved for starting and lighting when the generator is not running.

The control element is set at a certain voltage, usually 14½ volts, for summer operation, and at 15 or 15½ volts for winter operation, when the lights are burned during more hours in the day and the cold increases the battery resistance. A button acting on the control head serves for making this adjustment and is on the outside of the case so that the adjustment can be made in one or two seconds.

At this point the speaker gave a more detailed description of the regulating mechanism and made a number of demonstrations of the operation of the generator in charging a battery and of the effect of cutting the lighting load of a motorcoach in and out, with virtually no flickering of the light.

Replies to a Question Barrage

Following this, the barrage of questions was laid down. To some of these Mr. Cartwright replied that the speed of the generator when developing its full output is 1600 r.p.m. and that at its maximum speed it will deliver 40 amp.; that no passenger-cars are using this generator because the third-brush generator can be regulated so readily for the needs of those who use the starter a great deal and those who do not, and also because the control unit on the motorcoach generator is rather expensive; but he intimated that, with a production sufficient for private passenger-cars, the price could be substantially reduced. One important advantage, he said, is that if a wire breaks anywhere in the charging circuit the output of the generator is

controlled at once according to the load on it, and another is that the current for the lamps is materially increased. The danger of a driver being left in the dark by the breaking of a cable or wire is obviated. If a wire breaks in the daytime, an indicator shows that no current is going into the battery; at night, if it were known that the lamp-current load was 15 amp. and if the ammeter reading was 15 amp., the driver would know that the circuit was open somewhere and no current was going into the battery.

One of the lantern slides displayed showed a control unit on a generator in a taxicab. This type is used also with the third-brush generator for the smaller single-deck motorcoaches, and consists of a cut-out unit and a voltage-regulator unit. The taxicab unit is less expensive, as the third-brush is not needed.

High-Speed-Engine Circuit-Breaker

To gain the necessary high-speed action of the circuit breaker for ignition in the present high-speed engines, a double-direction ignition unit has been evolved, said Mr. Cartwright, which is connected in parallel so that the current is divided and one-half is carried by one set of breaker-points and the other half by another set. This means longer life for the breaker points and much less adjusting. By lengthening the breaker arm and increasing the spring tension, all chattering effects are virtually eliminated, according to Mr. Cartwright, who said, in response to inquiries, that records show operation for from 40,000 to 62,000 miles without any adjustment, after which it was necessary only to bring the contacts slightly closer together. The general voltage of the battery will vary a little with the capacity of the generator; if the battery is entirely too small, the generator voltage will be a little higher than with a battery of full size or slightly over-size. The generator voltage with the third-brush system and a 6-volt battery can go as high as 7.25 to 7.50 volts when charging without being detrimental; but the voltage drops to normal as the generator speed is decreased or when the engine is stopped.

Charging Rate with Three-Brush System

Some difficulty arises with the lighting system on old-type motor-trucks because batteries are being changed and charged in the garage, and they show one voltage when charging and another when discharging, said a member, who inquired if any incandescent lamps are being manufactured that give full candlepower at 6 volts. To this Mr. Cartwright replied that all 6-volt lamps are being manufactured on a 6½-volt basis; that charging rates should be set on a fully charged battery and while the generator is warm, as a charging rate of 15 amp. when it is warm will be 18 amp. when it is cold. The third-brush system operates directly opposite to the ideal condition, the charging rate on a discharged battery being lower than on a fully charged battery. Therefore, if the charging rate is set on the discharged battery at the full output of the generator, there is a possibility, on a small battery, of the charging rate increasing 75 per cent when the battery becomes charged; and this overloads the generator and results in heating the battery. The charging rate should be set with an ammeter connected to the generator terminal, if the generator has to be set up to its full capacity.

Evolution of Motorcoaches

Rapid Progress Reviewed at Metropolitan Section Meeting by Smith and Naegel

IN making a snapshot of a racing car in motion the focal-plane shutter of the camera exposes the bottom of the car before the top and produces the effect of leaning forward that we have come to associate with speed. In presenting his paper on Evolution of the Present-Day Motorcoach Chassis, G. W. Smith, Jr., of the White Motor Co., gave a corresponding idea of speed by saying that the evolution is so rapid that this is no time to get a view of the state of the art.

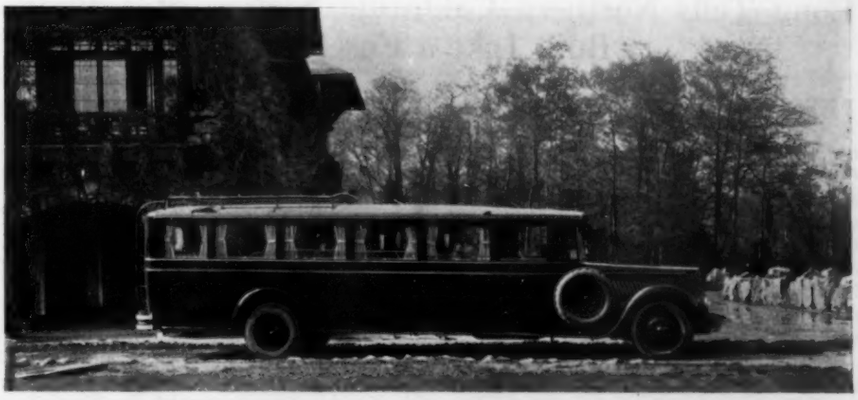
A helix, like the thin spiral of smoke rising from a cigarette, is taken as a symbol of motor-car evolution. Designers go over and over again the same old basic principles of design and arrangement, but, as a rule, some progress is made on each new turn. The important thing is to summarize the progress. Examples of this are found in the increase of front-axle tread to 78 in., of the tire size to the present 10.50-in. balloon, and of the wheelbase to a length of 240 in. or more. The powerplant has increased about 60 per cent in piston displacement and 125 per cent in output, and now it is a problem to get a sufficient radiator in the available space without making it too high for the driver to see over.

Opinions on several of the moot questions of design were given by Mr. Smith, who believes the gear transmission to be unchallenged for use in the intercity coach and to be still a competitor in urban transportation. Major improvements in gear transmissions are still possible. The steam motorcoach is making a bid for a place in the sun. While a steam engine offers the ideal torque characteristics, Mr. Smith's experience is that the many accessories such as thermostats, water-feeding devices and open-fire burners are more of a handicap to it than are the carbureter, ignition and other accessories to the internal-combustion engine.

How Motorcoach Bodies Have Been Developed

In W. G. Naegel's paper the author, who is connected with the Lang Body Co., sketched the development of the motorcoach body from the time when motorcoaches were made on the Pacific Coast by lengthening the frame and body of a passenger-car and adding more doors and seats to provide capacity for about 12 passengers.

The next step was to mount a sedan-type body on the chassis of a long-wheelbase truck. This did not prove satisfactory, because of high upkeep expense and because, with this type of body, it was too hard for the driver to look after so many passengers. This



De Luxe Interurban Motorcoach Operating Out of New York City

led to the present style of coach body in which the doors have been replaced with drop windows and a passage is provided between the seats.

Legal limitations are commonly placed on the size of motorcoaches. The maximum width is 96 in. and the maximum over-all length generally is 30 ft., although in several States it is 28 ft. The clear head-room is ordinarily 76 in. The resulting maximum seating capacity for a conventional city-type motorcoach is 29 to 33 passengers. Now the designer is faced with the problem of crowding seats for 35 or 40 passengers into the same space.

In Mr. Naegel's opinion, the original type of composite construction of wood reinforced with steel must now be superseded by all-metal construction, and he believes that the semi-rigid type will prove more economical in maintenance cost than will the rigid type of metal body.

Examples of a number of motorcoach bodies were shown on the screen by Mr. Naegel, including views showing the construction of partially built frames. Other slides showed a coach that had suffered damage from collision and depicted the relative ease with which repairs were made.

At the close of the meeting, Mr. Smith showed motion pictures of motorcoaches in service in Cleveland and elsewhere, including vehicles of a number of different makes, some having six and others eight wheels.

Why People Ride in Motorcoaches

During the technical session the meeting was in charge of C. W. Stokes, the member of the Section Meetings Committee who had arranged it. He remarked on the great growth in the patronage of motorcoach lines.

In the discussion, M. C. Horine, of the Mack Truck organization, analyzed the chairman's implied question as to the reason for this increase. He stated that the motorcoach is the great answer to the desire of middle-class people who want to ride in something better than the trolley-car and the day coach, yet cannot afford the expense of the taxicab and the Pullman with its 50-per cent surcharge.

Announcements at the Season's Wind-Up

Officers elected for next season were announced as follows: Chairman, S. R. Dresser; vice-chairman, George A. Round; treasurer, J. C. Morrell; and secretary, W. H. Conant.

Appreciation of the work of the officers and committee men during the year just ended was voiced. It is said that the membership of the Section now includes 90 per cent of the Society members living within the Section territory. Far from being disheartened because the Detroit Section now has a few more members than the Metropolitan, the Section in New York City feels satisfied that it has had some influence in stimulating development of the Section which has the largest constituency of any in the Society.

This final meeting of the season, attended by about 150 members, was held in the Building Trades Club on May 17, following a dinner attended by 115 members. At the close of the dinner General Manager Clarkson, of the Society, complimented the Section on the work it had done during the year and spoke briefly on the attractions to be offered at the Summer Meeting in Quebec.

A pleasing incident occurred when Chairman Ed Lowe called Miss McCormick and Miss Bell, of the Society staff, to the speakers' table to receive small caskets of gold, presented to them in appreciation of their work with the Metropolitan Section during the year.

Lighter Truck Bodies Wanted

Long Tells Northern California Section of a Body Built Like a Fuselage

INSPIRED by the story of the creation of Eve, J. F. Long exhibited the rib of an airplane at the Northern California Section meeting, on May 10, as the basis for the design of a light body for a motor-truck. As described by him, the body more nearly resembled conventional fuselage construction, but the rib evidently was more convenient than the fuselage to exhibit at the meeting.

Confirming the nominations made by the Nominating Committee, the following officers were elected to serve the Section for the year that is ahead: S. B. Shaw, Pacific Gas & Electric Co., chairman; Horace Hirschler, Horace Remote Control Co., vice-chairman; Herbert Miller, Sterling Motor Truck Co., vice-chairman for East Bay; Fred L. Sargent, White Co., treasurer; and W. S. Crowell, Home Accident Insurance Co., who was re-elected secretary.

Announcement was made that a smoker will be held on June 14. Among the things promised for this occasion are a good dinner, dancing numbers, and talks by the retiring chairman and the incoming chairman of the Section.

Following this announcement, Mr. Long told how his concern, Aircraft Industries, was called upon to build a body for the use of a florist on a chassis weighing 3242 lb., keeping the total weight below 4000 lb. The job was accomplished by resorting to airplane practice. The cab was made with a welded tubular steel frame covered with aluminum sheets held in place by drive-screws. The cab was supported on the frame at two points in the rear and on the cowl at a single point at the front.

Square steel tubing was used for the frame supporting the canopy of the body, and the floor was made of ¾-in. tongued and grooved spruce, glued with casein glue. Square tubing was used also for the three main cross-members, which were clamped directly to the frame with only brake lining interposed, and the floor-boards were screwed to the transverse members. A catch strip was welded to the corner supports and side pieces, and plywood siding was attached to this.

The body was 100 in. long and 62 in. wide and had side rails 14 in. high. The canopy was 6 ft. high inside, with heavy canvas curtains. The cab, with cushions, flooring, tank mountings, windows and cushions, weighed 140 lb. The canopy weighed 75 lb. and the body proper brought the total weight up to 500 lb. Costing about $120 more than an ordinary body, a saving of $1 was made on each crossing of the ferry because of keeping within the weight limitation. The saving amounted to $400 per year in this case.

The body withstood rough tests, and was used in service without breakage or trouble, but complaint was made that the vehicle rode too hard because of its light weight. Removing two leaves from each rear spring and adding shock-absorbers did not make the riding satisfactory, so the truck was put into the service of hauling dirt, gravel and rock, having a capacity of about 2½ cu. yds., and it proved serviceable at that work.

Although no aluminum was used in this job, except for the sheathing of the cab, Mr. Long mentioned the possibility of the use of duralumin castings in the production of light bodies for motor-trucks. Modern welding processes for steel also can be used to save much weight when compared with bolted connections.

Saving Weight in Usual Construction

How weight saving can be effected in a regular body-shop was next described by C. A. Wood of Wood Bros., Oakland. He stated that improper selection of the chassis for the particular job and insufficient consideration of factors such as wheelbase and load distribution are responsible for some of

(*Continued on p.* 728)

Reports of Divisions to Standards Committee

STANDARDS COMMITTEE MEETING JUNE 26

To Be Held in Connection with the Summer Meeting of the Society

In this issue of THE JOURNAL are printed reports that have been prepared for submission to the Standards Committee and to the Society by nine Divisions of the Standards Committee since the Annual Meeting last January.

All of the reports are submitted at this time for approval after having been considered carefully by the respective Divisions and given as wide publicity as possible by publication in this or previous issues of THE JOURNAL. The reports as now presented are believed to be in acceptable form and any proposals should be only in the nature of important and carefully considered constructive changes.

Under the Standards Committee procedure, these reports may be approved as presented, amended within limitations, or referred back to the respective Divisions for sufficient reason. The action taken on them by the Standards Committee will be passed upon by the Council and the general business session of the Society, with the purpose of approving them for submission to letter ballot of the members of the Society as the final step in their adoption. The letter ballot will be counted 30 days following the Standards Committee Meeting, and the reports on which the vote is affirmative will be published in the S.A.E. HANDBOOK.

Rejection or major changes in any of the reports will require that they be sent back to the Divisions that prepared them and that they cannot be passed upon again before the Annual Meeting of the Society next January. In voting on the reports at the Standards Committee Meeting, the Regulations require that only members of the Standards Committee do so.

Aeronautic Division

PERSONNEL

E. P. Warner, *Chairman*	Assistant Secretary of the Navy for Aeronautics
Arthur Nutt, *Vice-Chairman*	Curtiss Aeroplane & Motor Co.
Archibald Black	Garden City, N. Y.
V. E. Clark	Buffalo
J. W. Crowley, Jr.	Langley Field, Hampton, Va.
J. F. Hardecker	Navy Yard, Philadelphia
C. B. Harper, Lieut.	Bureau of Aeronautics
E. T. Jones	Wright Aeronautical Corporation
I. M. Laddon	Consolidated Aircraft Corporation
C. J. McCarthy	Chance Vought Corporation
Leslie MacDill, Major	Wright Field, Dayton, Ohio
W. B. Mayo	Ford Motor Co.
G. J. Mead	Pratt & Whitney Aircraft Co.
L. D. Seymour	National Air Transport Co.
R. H. Upson	Aircraft Development Corporation
Edward Wallace	Glenn L. Martin Co.
Karl H. White	Bellanca Aircraft Corporation of America
L. M. Woolson	Packard Motor Car Co.
T. P. Wright	Curtiss Aeroplane & Motor Co.
P. G. Zimmermann	Paul G. Zimmermann Metal Aircraft

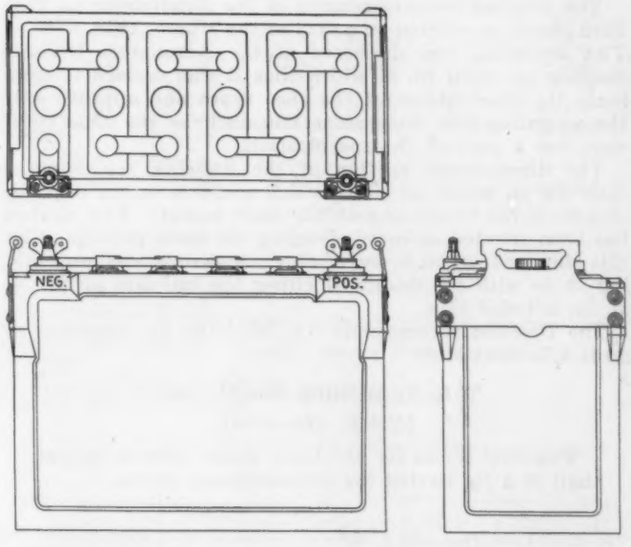
AIRCRAFT STORAGE-BATTERIES

After due consideration of the present types of aircraft battery being manufactured for military and commercial use, the Subdivision on Aircraft Storage-Batteries recommended to the Aeronautic Division a series of three sizes of non-spillable battery to be known as S.A.E. Nos. 32, 34 and 36.

The Division recommends the approval by the Standards Committee of the following aircraft-battery specifications as an S.A.E. Standard:

AIRCRAFT BATTERY SPECIFICATIONS

Aircraft Storage-Batteries.—These specifications are intended to apply only to lead-acid storage-batteries for aircraft.



Battery No.	Number of Cells	Minimum Capacity at 5-Hr. Rate, Amp.-Hr.	Minimum Current for 20 Min., Amp.	Maximum Over-All Dimensions, In.			Maximum Weight Wet, Lb.
				Length[1]	Width	Height	
32	6[a]	29½	50	8 1/16	7¼	11¼	38
34	6[a]	43	75	11½	7¼	11¼	53
36	6[a]	65	113	14½	7¼	11¼	70

[1] The over-all end-to-end length includes handles, not hold-down devices. The handles and the hold-down devices shall be attached only to the ends of the case.
[a] Side-to-side assembly of cells.

Ratings.—Batteries for combined starting and lighting service shall indicate the lighting ability and shall be the capacity in ampere-hours of the battery when it is discharged continuously at the 5-hr. rate to a final voltage of not less than 1.75 per cell, the temperature of the battery at the beginning of such discharge being 80 deg. fahr. The second rating shall indicate the starting ability and shall be the minimum current in amperes that the battery will deliver when discharged continuously at the 20-min. rating to a final voltage of not less than 1.5 per cell, the temperature of the battery at the beginning of such discharge being 80 deg. fahr.

Non-Spillable Feature.—Means shall be provided to prevent the escape of electrolyte when the battery is turned in an inverted position, or in any position between normal and the inverted position, and allowed to remain in any position for an indefinite period. During this test the electrolyte shall be adjusted to normal level.

Terminals.—Aircraft storage-batteries shall be equipped with wing-nut terminals secured to the top of the battery box in such a manner that vibrations from the external leads will be absorbed by the battery box and not transmitted to the terminal post. Both terminals shall be located on the same side of the battery, with the positive to the right when looking at the terminal side of the battery.

Terminals shall have a 5/16-13 American Standard thread, with tolerances providing a Class 2 fit.

Battery terminals and cable terminals shall be lead coated.

TAIL-SKID SHOES

The original recommendation of the Subdivision on Tail-Skid Shoes, as printed on p. 323 of the March, 1928, issue of THE JOURNAL, was discussed at the Aeronautic Division meeting on April 18, at which time it was decided to eliminate the illustrations of the shoe types and approve only the mounting-hole dimensions inasmuch as the shoe types were not a part of the specification.

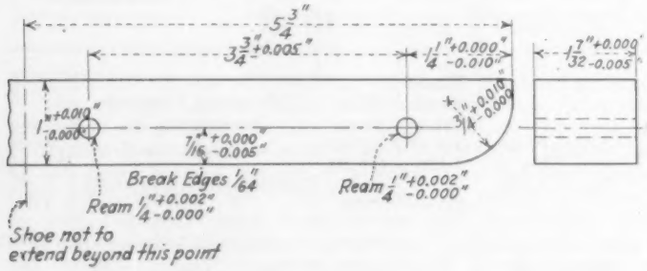
The dimensioned portion of the drawing represents a male jig on which all shoes which conform to the required standards for interchangeability must mount. This method has been selected as best indicating the basic principle that this standardization is one of dimensions only and has nothing to do with the design of either the tail-skid proper or of the tail-skid shoe.

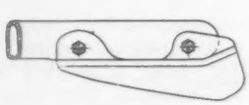
The Division recommends the following for approval as an S.A.E. Standard:

TAIL-SKID SHOE MOUNTINGS

(S.A.E. Standard)

Tail-Skid Shoes for airplanes under 4500-lb. weight shall fit a jig having the dimensions as shown.





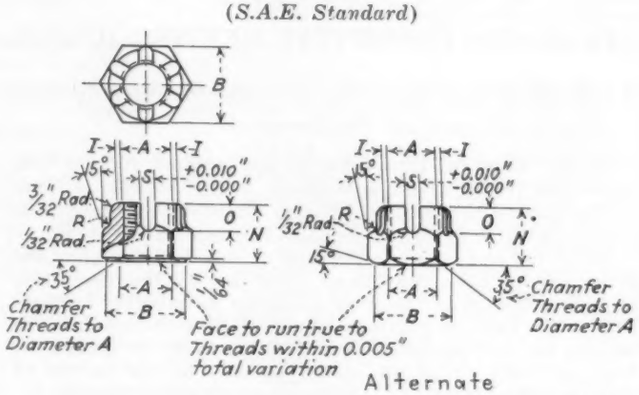
AERONAUTIC BOLTS AND NUTS

The Division recommends that the present S.A.E. Specifications on Castle Hexagon Nuts, Aeronautic, p. 286 of the 1928 edition of the S.A.E. HANDBOOK, be revised in accordance with the table shown and that these specifications be approved as an S.A.E. Standard. The revised specification is as follows:

CASTLE HEXAGON NUTS

AERONAUTIC

(S.A.E. Standard)



Alternate

Bolt Size *A*, Threads per Inch	B[1]	*N*	*S*	*O*[2]	*R*	*I*[3]
0.1640(No. 8)–36	3/8	15/64	5/64	9/64	3/32	1/64
0.1900(No. 10)–32	3/8	1/4	5/64	9/64	3/32	1/64
0.2500(1/4)–28	7/16	9/32	5/64	5/32	3/32	1/32
0.3125(5/16)–24	1/2	21/64	5/64	5/32	3/32	1/32
0.3750(3/8)–24	9/16	13/32	1/8	3/16	3/32	1/32
0.4375(7/16)–20	5/8	29/64	1/8	3/16	3/32	3/64
0.5000(1/2)–20	3/4	9/16	1/8	13/64	1/8	3/64
0.5625(9/16)–18	7/8	39/64	5/32	7/32	5/32	3/64
0.6250(5/8)–18	15/16	11/16	5/32	7/32	5/32	3/64

[1] Also size of hexagon.
[2] Also depth of slot.
[3] Distance from *A* to beginning of 3/32-in. radius, whose center is floating to satisfy curve.

All threads are American Standard (NF), with Class 3 Tolerances. All dimensions in inches. Tolerances are ±0.010 in. except where otherwise indicated.

Physical Properties.—Nuts shall be manufactured from bar steel having the following physical properties:

Tensile strength (minimum) lb. per sq. in. 70,000
Yield point (minimum) lb. per sq. in. 50,000
Elongation (minimum) in 2 in., per cent 10
Reduction of Area (minimum) per cent 40

Nuts shall withstand being increased 25 per cent of their original internal diameter without fracture and decreased 25 per cent of their internal diameter without failure.

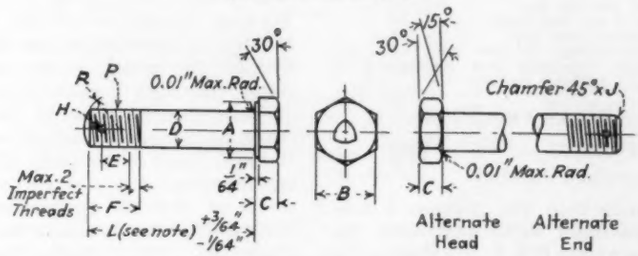
PLAIN HEXAGON-HEAD BOLTS

AERONAUTIC

(S.A.E. Standard)

The Division also recommends that the present S.A.E. Specifications on Plain Hexagon-Head Bolts and Nuts, pp. 288 and 289 of the 1928 edition of the S.A.E. HANDBOOK, be revised to conform to the dimensions shown and approved as an S.A.E. Standard. The revised specification is as follows:

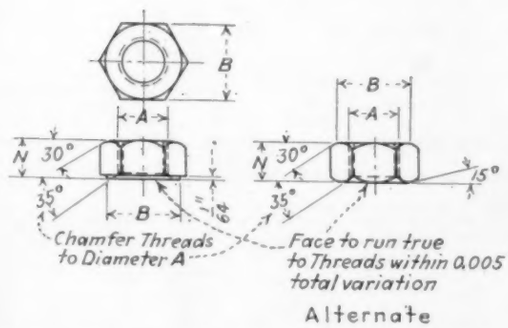
PLAIN HEXAGON-HEAD BOLTS, AERONAUTIC
(*S.A.E. Standard*)



Nominal Bolt Size	Threads per In.[1]	*A*	*B*	*C*	*D*[2]	*E*	*F*	*H*	*J*	*R*	Tensile[3] Strength, Minimum, Lb.
0.1640 (No. 8)	36	5/16	5/16	1/8	0.164+0.0000 −0.0030	7/32	3/8	0.070	1/32	1/8	— —
0.1900 (No. 10)	32	3/8	3/8	1/8	0.190+0.0000 −0.0054	1/4	3/8	0.070	1/32	3/16	2,190
0.2500 (1/4)	28	7/16	7/16	5/32	0.250+0.0000 −0.0062	9/32	7/16	0.076	1/32	1/4	4,070
0.3125 (5/16)	24	1/2	1/2	3/16	0.3125+0.0000 −0.0066	21/64	7/16	0.076	3/64	5/16	6,550
0.3750 (3/8)	24	9/16	9/16	7/32	0.375+0.0000 −0.0066	13/32	9/16	0.106	3/64	3/8	10,100
0.4375 (7/16)	20	5/8	5/8	1/4	0.4375+0.0000 −0.0072	29/64	9/16	0.106	3/64	7/16	13,620
0.5000 (1/2)	20	3/4	3/4	9/32	0.500+0.0000 −0.0072	9/16	11/16	0.106	3/64	1/2	18,580
0.5625 (9/16)	18	7/8	7/8	5/16	0.5625+0.0000 −0.0082	39/64	3/4	0.141	3/64	9/16	23,600
0.6250 (5/8)	18	15/16	15/16	11/32	0.625+0.0000 −0.0082	11/16	13/16	0.141	3/64	5/8	30,000

Bolt lengths 1/4 to 8 in. by 1/4-in. increments.
Where *L* is shorter than *F*, bolt is to be threaded entire length.
[1] Threads are American Standard (NF), with Class 3 tolerances.
[2] Finished sizes include plating or protective coating.
[3] *Physical Properties.*—Assembled bolts shall show required minimum tensile-strength when tested in tension between the head and the nut.
Bolts shall stand cold-bending in the plain part without fracture through an angle of 180 deg. over a diameter equal to the diameter of the bolt. In short bolts the test may be made in threaded part.
Marking.—Bolts conforming to these specifications shall be marked with a triangle as shown.
Bolts conforming entirely to Army-Navy material specifications shall be marked with X in place of the triangle.
Bolts not marked in either manner will be understood to be made from low-strength material.

PLAIN HEXAGONAL NUTS
AERONAUTIC
(*S.A.E. Standard*)



Nominal Size A[2]	Threads per Inch[3]	*B* Width Across Flats	*N*[1] Full-Strength Nuts ±0.005	*N*[1] Thin and Check Nuts ±0.005
0.1640 (No. 8)	36	3/8	1/8	1/8
0.1900 (No. 10)	32	3/8	9/64	9/16
0.2500–1/4	28	7/16	3/16	1/8
0.3125–5/16	24	1/2	15/64	5/32
0.3750–3/8	24	9/16	9/32	3/16
0.4375–7/16	20	5/8	21/64	7/32
0.5000–1/2	20	3/4	3/8	1/4
0.5625–9/16	18	7/8	27/64	9/32
0.6250–5/8	18	15/16	15/32	5/16

[1] For full-strength nuts $N=3A/4$. For check nuts and thin nuts for shear bolts 1/4 in. diameter and larger $N=A/2$.
[2] Finished sizes include plating or protective coating.
[3] Threads are American Standard (NF), with Class 3 tolerances.
All dimensions in inches. Tolerances are ±0.010 except where otherwise indicated.

Physical Properties.—Nuts shall be manufactured from bar steel having the following physical properties:

Tensile strength (minimum), lb. per sq. in.	70,000
Yield point (minimum), lb. per sq. in.	50,000
Elongation (minimum), in 2 in., per cent	10
Reduction of Area, (minimum) per cent	40

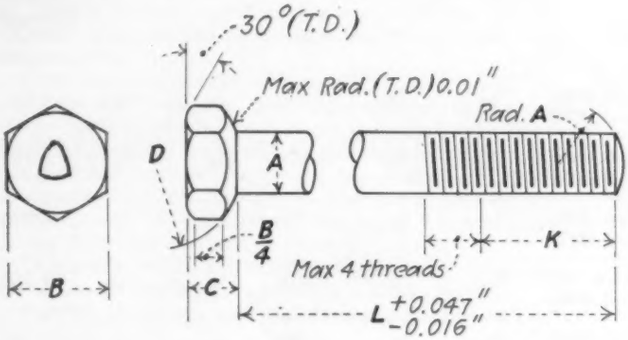
Nuts shall withstand being increased 25 per cent of their original internal diameter without fracture and decreased 25 per cent of their internal diameter without failure.

Ball Hexagon-Head Bolts and Nuts

AERONAUTIC

(*S.A.E. Recommended Practice*)

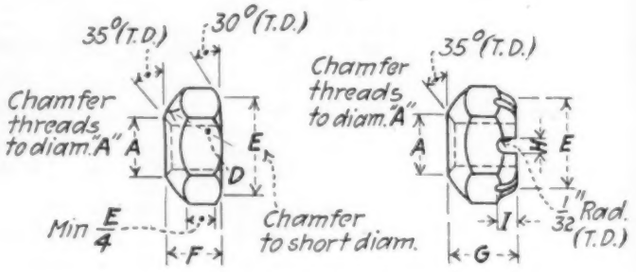
The Division also recommends that the present S.A.E. Specifications on Ball Hexagon-Head Bolts and Nuts, pp. 290 and 291 of the 1928 edition of the S.A.E. Handbook, be revised as follows:



SMALL AIRCRAFT-FITTINGS

A Subdivision under the Chairmanship of Edward P. Warner, Chairman of the Aeronautic Division, was appointed to recommend specifications on hardware and small fittings for which there are existing AN Specifications. After thorough consideration of such standards, the Subdivision recommended to the Division the adoption of the AN dimensional Specifications on Eye-Bolts, Flat Washers, Pulleys, Rigid Terminals, Shackles and Turnbuckles. The specifications are also to include material requirements in terms of physical properties and a method of marking to distinguish the products made according to the physical-properties specifications from those made of low-strength steel.

The Division recommends the approval as S.A.E. Standards of the specifications on the following page.



Nominal Bolt Size, *A*	Threads per Inch[1]	Bolt Diameter Limits, *A*[2]	*B* Width Across Flats	*D*	*D* Radius	*E* Width Across Flats	*F* Ball Hexagon Nuts	Ball Castle Nuts			Tensile Strength (Minimum)[4]
								G[3]	*H*	*I*	
0.1640 (No. 8)	36	0.1640+0.0000 −0.0030	5/16	11/64	3/8	3/8	11/64	1/4	5/64	5/64	— — —
0.1900 (No. 10)	32	0.1900+0.0000 −0.0054	3/8	11/64	3/8	3/8	11/64	1/4	5/64	5/64	2,190
0.2500 (1/4)	28	0.2500+0.0000 −0.0062	7/16	13/64	3/8	7/16	13/64	19/64	5/64	3/32	3,070
0.3125 (5/16)	24	0.3125+0.0000 −0.0066	1/2	1/4	3/8	1/2	1/4	11/32	5/64	3/32	6,550
0.3750 (3/8)	24	0.3750+0.0000 −0.0066	9/16	5/16	1/2	9/16	5/16	7/16	1/8	1/8	10,100
0.4375 (7/16)	20	0.4375+0.0000 −0.0072	11/16	23/64	1/2	5/8	23/64	31/64	1/8	1/8	13,620
0.5000 (1/2)	20	0.5000+0.0000 −0.0072	3/4	3/8	1/2	3/4	3/8	9/16	1/8	3/16	18,580
0.5625 (9/16)	18	0.5625+0.0000 −0.0082	7/8	15/32	5/8	7/8	15/32	21/32	5/32	3/16	23,600
0.6250 (5/8)	18	0.6250+0.0000 −0.0082	15/16	33/64	5/8	15/16	33/64	49/64	5/32	1/4	30,000

[1] Threads are American Standard (NF), with Class 3 tolerances.
[2] Finished sizes include plating or protective coating.
[3] $G=F+I$.
[4] *Physical Properties.*—Assembled bolts shall show required minimum tensile-strength when tested in tension between the head and the nut.

Bolts shall stand cold-bending in the plain part without fracture through an angle of 180 deg. over a diameter equal to the diameter of the bolt. In short bolts the test may be made in threaded part.

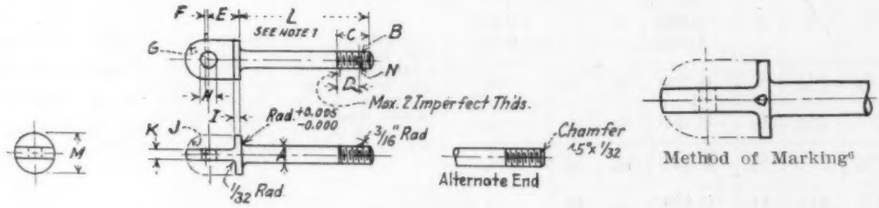
Marking.—Bolts conforming to these specifications shall be marked with a triangle as shown.

Bolts conforming entirely to Army-Navy material specifications shall be marked with X in place of the triangle.

Bolts not marked in either manner will be understood to be made from low-strength material.

EYE-BOLTS

(S.A.E. Standard)



A[2] Bolt Diameter	Tensile Strength, Lb.[5] (Min.)	B[4] Thread	C Thread Length See Note 2	D	E	F	G Rad.	H	I	J Rad.	K	N Drill Size	M
0.190 +0.0000 −0.0054	2,190	10-32	3/8	1/4	13/32	1/32	7/32	0.188+0.010 −0.000	1/16	7/32	0.094 ±0.005	No. 50 (0.070)	7/16
0.250 +0.0000 −0.0062	4,070	1/4-28	7/16	9/32	15/32	1/32	1/4	0.188+0.010 −0.000	5/64	1/4	0.125 ±0.005	No. 48 (0.076)	1/2
0.3125+0.0000 −0.0066	6,550	5/16-24	7/16	21/64	17/32	3/64	5/16	0.250+0.010 −0.000	3/32	5/16	0.188 ±0.005	No. 48 (0.076)	5/8
0.3125+0.0000 −0.0066	10,100	5/16-24	7/16	21/64	19/32	3/64	11/32	0.313+0.010 −0.000	3/32	11/32	0.188 ±0.005	No. 48 (0.076)	11/16
0.375 +0.0000 −0.0066	13,620	3/8-24	9/16	13/32	19/32	3/64	3/8	0.375+0.010 −0.000	3/32	3/8	0.188 ±0.005	No. 36 (0.106)	3/4
0.4375+0.0000 −0.0072	18,580	7/16-20	9/16	29/64	23/32	1/16	7/16	0.375+0.010 −0.000	1/8	7/16	0.250 ±0.005	No. 36 (0.106)	7/8
0.500 +0.0000 −0.0072	23,600	1/2-20	11/16	9/16	13/16	1/16	1/2	0.4375+0.010 −0.000	1/8	1/2	0.3125 ±0.005	No. 36 (0.106)	1
0.5625+0.0000 −0.0072	30,000	9/16-18	3/4	39/64	15/16	5/64	19/32	0.500+0.010 −0.000	1/8	19/32	0.375 ±0.005	No. 28 (0.141)	1 3/16

[1] Standard bolt lengths (*L*) 1/4 to 8 in. by 1/4-in. increments. Tolerances on length, +3/64, —1/64

[2] Where length of bolt (*L*) is shorter than *C* (thread length), bolt is to be threaded entire length.

[3] Finished sizes include plating or protective coating.

[4] Threads are American Standard (NF), with Class 3 tolerances.

All dimensions in inches. Tolerances are ±0.010 except where otherwise indicated.

[5] *Physical Properties.*—Assembled bolts shall show required minimum tensile-strength when tested in tension between the head and the nut

Bolts shall stand cold-bending in the plain part without fracture through an angle of 180 deg. over a diameter equal to the diameter of the bolt. In short bolts the test may be made in threaded part.

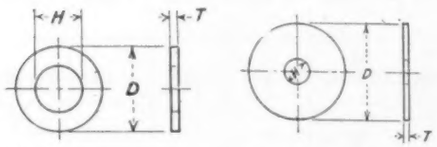
[6] *Marking.*—Bolts conforming to these specifications shall be marked with a triangle, as shown.

Bolts conforming entirely to Army-Navy material specifications shall be marked with X in place of the triangle.

Bolts not marked in either manner will be understood to be made from low-strength material.

FLAT WASHERS

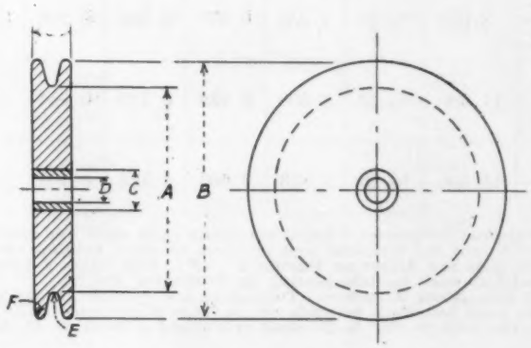
(S.A.E. Standard)



Nominal Bolt Size	H	Large		Small	
		D	T	D	T
No. 8	11/64	....	....	5/16	1/32
No. 10	13/64	7/8	1/16	3/8	1/32
1/4	17/64	1 1/8	1/16	1/2	1/16
5/16	21/64	1 3/8	1/16	9/16	1/16
3/8	25/64	1 5/8	1/16	11/16	1/16
7/16	29/64	1 13/16	1/10	13/16	1/16
1/2	33/64	2	1/10	15/16	1/16
9/16	37/64	2 3/16	1/8	1 1/16	1/16
5/8	41/64	2 3/8	1/8	1 1/8	1/16

PULLEYS, NON-METALLIC

(S.A.E. Standard)



(See p. 702 for table)

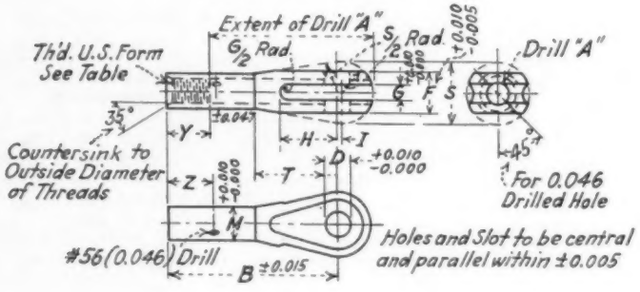
(*See p. 701 for cut*)

No.	Cable Size	*A*	*B*	*C*	*D* +0.002 −0.002	*E*	*F*	*G* +0.015 −0.015
1	1/16-3/32	7/8	1 1/4	3/8	0.253	3/64	1/32	17/64
2	1/16-3/32	2	2 1/2	3/8	0.253	3/64	1/32	17/64
3	1/8-5/32-3/16	1 3/8	2	1/2	0.378	7/64	3/64	7/16
4	1/8-5/32-3/16	2 7/8	3 1/2	1/2	0.378	7/64	3/64	7/16

Pulley 1. To be used for 1/32 and 3/32 extra flexible cable where the bend is 30° or less.
Pulley 2. To be used for 1/32 and 3/32 extra flexible cable where the bend is greater than 30°.
Pulley 3. To be used for 1/8, 5/32 and 3/16 extra flexible cable where the bend is 20° or less.
Pulley 4. To be used for 1/8, 5/32 and 3/16 extra flexible cable where the bend is greater than 30°.

RIGID TERMINALS

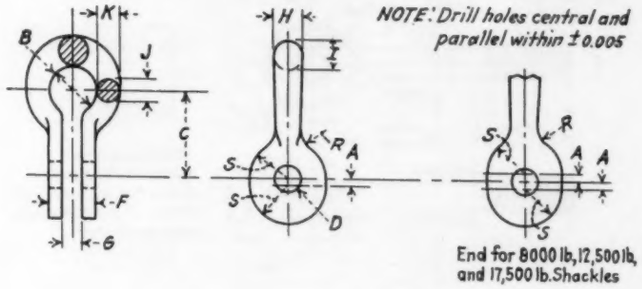
(*S.A.E. Standard*)



Hand	Tensile Strength, Minimum[1]	Thread[2]	*B*	*D*	*F*	*G*	*H*	*I*	Drill *A*	Drill for Threads	*M*	*S*	*T*	*Y*	*Z*
L.H. R.H.	1,000	6–40	1.313	0.188	0.250	0.109	0.375	0.031	0.147	No. 33 0.1130	0.250	0.375	0.625	0.250 1/4	0.313
L.H. R.H.	2,100	10–32	1.532	0.188	0.313	0.150	0.469	0.031	0.199	No. 21 0.1590	0.281	0.500	0.719	0.313 5/16	0.375
L.H. R.H.	3,400	1/4–28	1.813	0.250	0.438	0.203	0.625	0.047	0.261	No. 3 0.2130	0.375	0.625	0.875	0.438 7/16	0.500
L.H. R.H.	4,600	5/16–24	1.875	0.313	0.500	0.203	0.656	0.047	0.323	0.2703	0.438	0.688	0.938	0.563 9/16	0.625
L.H. R.H.	6,100	5/16–24	2.000	0.375	0.563	0.203	0.843	0.063	0.323	0.2703	0.453	0.750	1.000	0.563 9/16	0.625
L.H. R.H.	8,000	3/8–24	2.250	0.375	0.563	0.266	0.875	0.063	0.386	Q 0.3320	0.547	0.875	1.125	0.688 11/16	0.750
L.H. R.H.	11,500	7/16–20	2.500	0.438	0.719	0.344	1.000	0.078	0.453	W 0.3360	0.625	1.063	1.250	0.750 3/4	0.813
L.H. R.H.	15,500	1/2–20	2.813	0.500	0.813	0.406	1.183	0.078	0.516	0.4492	0.703	1.188	1.438	0.875 7/8	0.938

[1] *Physical Properties.*—Rigid terminals shall show the required minimum tensile-strength when tension is applied through a stay screwed into the terminal and eye-bolt or plate holding the clevis pin in the fork end.
[2] Threads are American Standard (NF), with Class 3 tolerances.
Finished sizes include plating or protective coating.
All dimensions in inches. Tolerances are ±0.010, except where otherwise indicated.
The bend test shall be made on the unbroken forked terminal by bending each side outward from its original position. The terminals from the 6-40 to the 1/2-20 shall withstand a bend of 45 deg.; the 5/8-18 and 5/8-18, a bend of 15 deg., without cracking.

SHACKLES
(*S.A.E. Standard*)



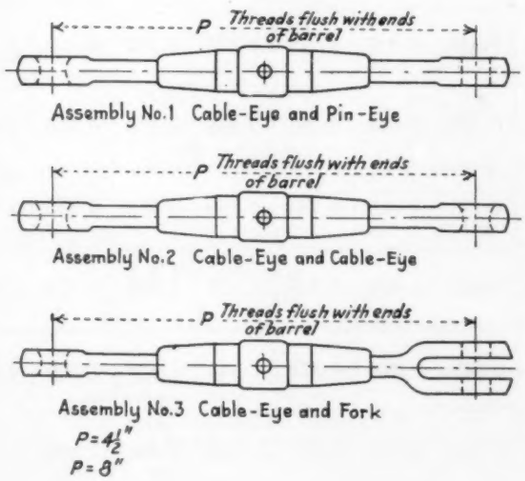
No.	Shackle and Cable Strength[1], Lb.	*D* +0.010 −0.000	*G* +0.010 −0.000	*F*	*S*	*J*	*K*	*H*	*I*	*A*	*B*	*C*	*R*
8	800	0.188	0.109	0.250	0.250	0.172	0.172	0.172	0.172	0.031	0.250	0.563	0.375
16	1,600	0.188	0.150	0.313	0.250	0.172	0.172	0.172	0.172	0.031	0.250	0.563	0.375
21	2,100	0.188	0.150	0.313	0.281	0.172	0.172	0.172	0.172	0.031	0.250	0.563	0.375
32	3,200	0.250	0.203	0.438	0.313	0.219	0.219	0.250	0.250	0.031	0.375	0.750	0.438
46	4,600	0.313	0.203	0.500	0.375	0.219	0.219	0.281	0.281	0.063	0.438	0.813	0.500
61	6,100	0.375	0.203	0.563	0.375	0.281	0.281	0.313	0.313	0.063	0.500	0.875	0.500
80	8,000	0.375	0.266	0.563	0.406	0.375	0.375	0.438	0.375	0.063	0.438	1.000	0.406
125	12,500	0.438	0.360	0.719	0.531	0.469	0.469	0.594	0.469	0.094	0.625	1.125	0.750
175	17,500	0.500	0.406	0.813	0.625	0.563	0.563	0.688	0.563	0.125	0.625	1.250	0.500

[1] *Physical Properties.*—Shackles shall show the ultimate strength required when subjected to a tensile test. Shackles, when subjected to a bend test made by opening the shackle and bending flat, shall show no signs of cracking.

Finished sizes include plating or protective coating.

All dimensions in inches. Tolerances are ±0.010 except where otherwise indicated.

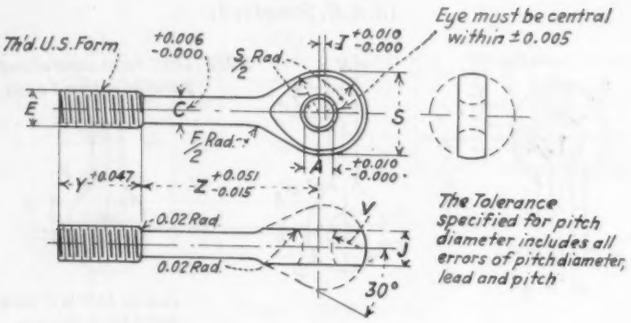
TURNBUCKLES
(*S.A.E. Standard*)



TURNBUCKLE WEIGHTS
(*General Information*)

Strength, Lb.	Approximate Weight, Lb.
Short Type	
800	0.030
1,600	0.065
2,100	0.084
3,200	0.112
4,600	0.165
Long Type	
1,600	0.094
2,100	0.116
3,200	0.172
4,600	0.250
6,100	0.368
8,000	0.420
12,500	0.630
17,500	0.935

CABLE EYE



Short

Hand	Strength, Lb.	Thread[1]	E	A	C	F/2	I	J	S	V	Y	Z
L. H. / R. H.	800	6–40	0.138 +0.0000 −0.0048	0.188	0.094	0.125	0.031	0.125	0.375	0.094	0.375	1.125
L. H. / R. H.	1,600	10–32	0.190 +0.0000 −0.0054	0.219	0.133	0.156	0.031	0.188	0.500	0.172	0.500	1.125
L. H. / R. H.	2,100	12–28	0.216 +0.0000 −0.0062	0.219	0.155	0.156	0.031	0.188	0.500	0.172	0.563	1.125
L. H. / R. H.	3,200	¼–28	0.250 +0.0000 −0.0062	0.281	0.189	0.219	0.047	0.219	0.625	0.203	0.625	1.125
L. H. / R. H.	4,600	5/16–24	0.3125 +0.0000 −0.0066	0.313	0.243	0.250	0.047	0.281	0.688	0.250	0.750	1.125

Long

L. H. / R. H.	1,600	10–32	0.190 +0.0000 −0.0054	0.219	0.133	0.156	0.031	0.188	0.500	0.172	0.500	2.000
L. H. / R. H.	2,100	12–28	0.216 +0.0000 −0.0062	0.219	0.155	0.156	0.031	0.188	0.500	0.172	0.563	2.000
L. H. / R. H.	3,200	¼–28	0.250 +0.0000 −0.0062	0.281	0.189	0.219	0.047	0.219	0.625	0.203	0.625	2.000
L. H. / R. H.	4,600	5/16–24	0.3125 +0.0000 −0.0066	0.313	0.243	0.250	0.047	0.281	0.688	0.250	0.750	2.000
L. H. / R. H.	6,100	3/8–24	0.375 +0.0000 −0.0066	0.344	0.256	0.281	0.063	0.281	0.750	0.313	0.875	2.000
L. H. / R. H.	8,000	3/8–24	0.375 +0.0000 −0.0066	0.375	0.306	0.281	0.063	0.328	0.875	0.375	0.875	2.000
L. H. / R. H.	12,500	7/16–20	0.4375 +0.0000 −0.0000	0.469	0.362	0.359	0.078	0.375	1.063	0.453	1.000	2.375
L. H. / R. H.	17,500	½–20	0.500 +0.0000 −0.0072	0.563	0.425	0.406	0.078	0.469	1.188	0.500	1.000	2.625

[1] Threads are American Standard (NF), with Class 3 tolerances.

Finished sizes include plating or protective coating.

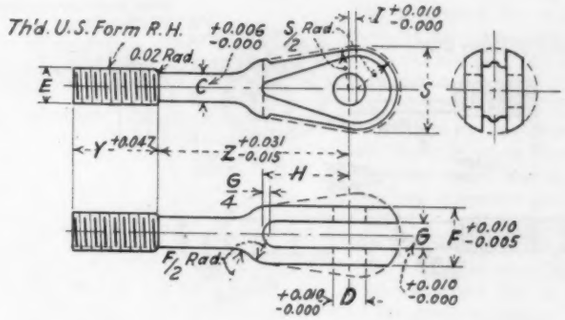
All dimensions in inches. Tolerances are ±0.010 except where otherwise indicated.

Physical Properties.—Turnbuckle cable-eyes shall be subjected to a tensile test after plating and shall withstand the test load specified.

The shanks shall be machined preferably from heat-treated cold-drawn or cold-rolled bars. If shanks are not made from heat-treated cold-drawn or cold-rolled bars, they shall be heat-treated after machining to give the physical properties specified.

Turnbuckle shanks meeting the tensile test without breaking shall be held in a square-nose vise and bent through an angle of 90 deg. without failing or cracking.

FORK



Short

Strength, Lb.	Thread[1]	*E*	*C*	*D*	*F*	*G*	*H*	*I*	*S*	*Y*	*Z*
800	6–40	0.138 +0.0000 −0.0048	0.094	0.188	0.250	0.109	0.375	0.031	0.375	0.375	1.125
1,600	10–32	0.190 +0.0000 −0.0054	0.133	0.188	0.313	0.150	0.469	0.031	0.500	0.500	1.125
2,100	12–28	0.216 +0.0000 −0.0062	0.155	0.188	0.313	0.150	0.562	0.031	0.500	0.563	1.125
3,200	1/4–28	0.250 +0.0000 −0.0062	0.189	0.250	0.438	0.203	0.625	0.047	0.625	0.625	1.125
4,600	5/16–24	0.3125+0.0000 −0.0066	0.243	0.313	0.500	0.203	0.656	0.047	0.688	0.750	1.125

Long

1,600	10–32	0.190 +0.0000 −0.0054	0.133	0.188	0.313	0.150	0.469	0.031	0.500	0.500	2.000
2,100	12–28	0.216 +0.0000 −0.0062	0.155	0.188	0.313	0.150	0.562	0.031	0.500	0.563	2.000
3,200	1/4–28	0.250 +0.0000 −0.0062	0.189	0.250	0.438	0.203	0.625	0.047	0.625	0.625	2.000
4,600	5/16–24	0.3125+0.0000 −0.0066	0.243	0.313	0.500	0.203	0.656	0.047	0.688	0.750	2.000
6,100	3/8–24	0.375 +0.0000 −0.0066	0.256	0.375	0.563	0.203	0.843	0.063	0.750	0.875	2.000
8,000	3/8–24	0.375 +0.0000 −0.0066	0.306	0.375	0.563	0.266	0.875	0.063	0.875	0.875	2.000
12,500	7/16–20	0.4375+0.0000 −0.0072	0.362	0.438	0.719	0.344	1.000	0.078	1.063	1.000	2.375
17,500	1/2–20	0.500 +0.0000 −0.0072	0.425	0.500	0.813	0.406	1.188	0.078	1.188	1.000	2.625

[1] Threads are American Standard (NF), with Class 3 tolerances.

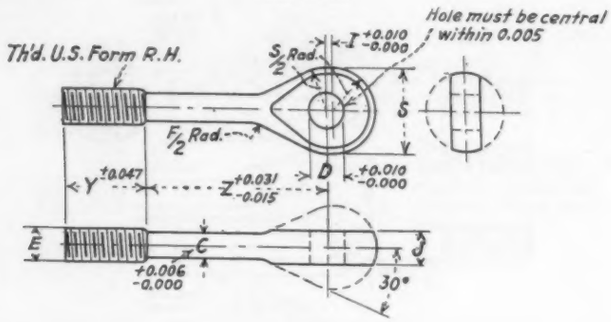
Finished sizes include plating or protective coating.

All dimensions in inches. Tolerances are ±0.010 except where otherwise indicated.

Physical Properties.—Turnbuckle forks shall be subjected to a tensile test after plating and shall withstand the test load specified. The forks shall be machined preferably from heat-treated cold-drawn or cold-rolled bars. If forks are not made from heat-treated cold-drawn or cold-rolled bars, they shall be heat-treated after machining to give the physical properties specified.

Turnbuckle forks meeting the tensile test without breaking shall be held in a square-nose vise, and bent through an angle of 90 deg. without failing or cracking.

PIN EYE



Short

Strength, Lb.	Thread[1]	Pitch Diameter	*D*	*C*	*F*/2	*I*	*J*	*S*	*Y*	*Z*
800	6–40	0.1218+0.0000 −0.0017	0.188	0.094	0.125	0.031	0.125	0.375	0.375	1.125
1,600	10–32	0.1697+0.0000 −0.0019	0.188	0.133	0.156	0.031	0.188	0.500	0.500	1.125
2,100	12–28	0.1928+0.0000 −0.0022	0.188	0.155	0.156	0.031	0.188	0.500	0.563	1.125
3,200	¼–28	0.2268+0.0000 −0.0022	0.250	0.189	0.219	0.047	0.219	0.625	0.625	1.125
4,600	5/16–24	0.2854+0.0000 −0.0024	0.313	0.243	0.250	0.047	0.281	0.688	0.750	1.125

Long

1,600	10–32	0.1697+0.0000 −0.0019	0.188	0.133	0.156	0.031	0.188	0.500	0.500	2.000
2,100	12–28	0.1928+0.0000 −0.0022	0.188	0.155	0.156	0.031	0.188	0.500	0.563	2.000
3,200	¼–28	0.2260+0.0000 −0.0022	0.250	0.189	0.219	0.047	0.219	0.625	0.625	2.000
4,600	5/16–24	0.2854+0.0000 −0.0024	0.313	0.243	0.250	0.047	0.281	0.688	0.750	2.000
6,100	⅜–24	0.3479+0.0000 −0.0024	0.375	0.256	0.281	0.063	0.281	0.750	0.875	2.000
8,000	⅜–24	0.3479+0.0000 −0.0024	0.375	0.306	0.281	0.063	0.328	0.875	0.875	2.000
12,500	7/16–20	0.4050+0.0000 −0.0026	0.438	0.362	0.359	0.078	0.375	1.063	1.000	2.375
17,500	½–20	0.4675+0.0000 −0.0026	0.500	0.425	0.406	0.078	0.469	1.188	1.000	2.625

[1] Threads are American Standard (NF), with Class 3 tolerances.

Finished sizes include plating or protective coating.

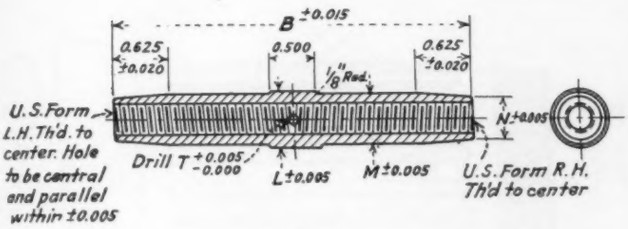
All dimensions in inches. Tolerances are ±0.010 except where otherwise indicated.

Physical Properties.—Turnbuckle pin-eyes shall be subjected to a tensile test after plating and shall withstand the test load specified.

The pin eye shall be machined preferably from heat-treated cold-drawn or cold-rolled bars. If pin eyes are not made from heat-treated cold-drawn or cold-rolled bars, they shall be heat-treated after machining to give physical properties specified.

Turnbuckle pin-eyes meeting the tensile test without breaking shall be held in a square-nose vise and bent through an angle of 90 deg. without failing or cracking.

BARREL



Short

Strength, Lb.	Thread[1]	L	M	N	B	T
800	6–40	0.250	0.219	0.188	2.25	0.125
1,600	10–32	0.375	0.281	0.250	2.25	0.125
2,100	12–28	0.375	0.328	0.281	2.25	0.125
3,200	¼–28	0.438	0.391	0.328	2.25	0.125
4,600	5/16–24	0.500	0.438	0.406	2.25	0.125

Long

1,600	10–32	0.375	0.281	0.250	4.00	0.125
2,100	12–28	0.375	0.328	0.281	4.00	0.125
3,200	¼–28	0.438	0.391	0.328	4.00	0.125
4,600	5/16–24	0.500	0.438	0.406	4.00	0.125
6,100 8,000	3/8–24	0.625	0.594	0.469	4.00	0.125
12,500	7/16–20	0.750	0.688	0.563	4.25	0.188
17,500	½–20	0.875	0.813	0.625	4.25	1.88

[1] Threads are American Standard (NF), with Class 3 tolerances. All dimensions in inches. Tolerances are ±0.010 except where otherwise indicated.

Physical Properties.—Barrels shall be made of rolled brass to provide the following physical properties:

Tensile strength (minimum), lb. per sq. in.	67,000
Yield point (minimum), lb. per sq. in.	45,000
Elongation (minimum) in 2 in., per cent	22
Reduction of area (minimum), per cent	45

PROPELLER HUBS

By far the most important subject taken under consideration by the Aeronautic Division is that of propeller-hub shaft ends to secure interchangeability of propellers on engines of the same general size.

The Subdivision, which was appointed under the Chairmanship of Capt. L. M. Woolson, of the Packard Motor Car Co., to study the various existing shaft ends with a view to determining a series of standard designs, presented at the Aeronautic Division meeting a report involving four specifications.

The first specification is a taper suitable for and in use on low-horsepower engines such as Curtiss OX-5, Pitcairn, Floco, LeBlond and Allison. While tapers are not generally regarded as highly satisfactory for the mounting of propellers, this size was included in view of its apparent widespread use on engines of the type mentioned.

The proposed No. 2 shaft end, as submitted in the original report, is also a taper, the dimensions of which conform to the shaft ends of the Wright Whirlwind engine and the Curtiss C-6. Developments occurring since the Subdivision's report was prepared have indicated the elimination, in the near future, of this design in favor of a spline shaft, as this latter type of shaft end represents better design. It is therefore suggested that the proposed No. 2 design, as shown, be eliminated from consideration with the understanding that at the next Standards Committee meeting the details of a spline shaft for engines of this class be submitted for consideration.

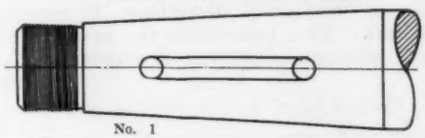
The proposed No. 3 shaft, as incorporated in the original report, is an eight-spline design which heretofore has found considerable use. As a result of the changes and developments referred to in the comments on the No. 2 design, it seems unwise at this time to accept this design as a standard. While no decision has been reached for engines in this class, there is some likelihood that a 16-spline shaft end that is shorter may be adopted generally by engine builders. Therefore it seems advisable that no action be taken on the proposed No. 3 design until further consideration has been given to the possibility of approving a short 16-spline shaft in place of this specification.

The proposed No. 4 16-spline shaft end is well standardized in practice today and is the generally accepted shaft end for engines of larger size.

The Division recommends that consideration be given by the Standards Committee only to the Nos. 1 and 4 proposed shaft ends, permitting the Division and Subdivision to undertake further developments on the Nos. 2 and 3 sizes. It has been suggested that the No. 1 taper also be eliminated from S.A.E. Standards in the belief that the use of this will ultimately be discontinued and that to adopt it as a standard might hinder its elimination in favor of the spline design.

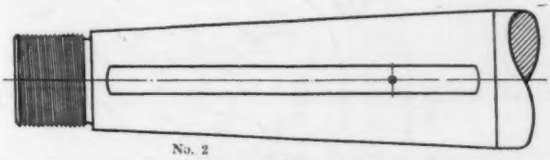
It is possible that the Division, working with the Subdivision, may be able to complete a new proposed No. 3 design prior to the Standards Committee Meeting. If so, this will be presented to the Standards Committee as a special item and will not be incorporated in these reports. The entire original report is published herewith for information, with the understanding that when the specifications are printed in the S.A.E. HANDBOOK they will be in the form of working drawings for each of the shaft ends approved, such drawings to include limits and tolerances or dimensions affecting the interchangeability rather than the basic dimensions as given herewith.

PROPELLER-HUB SHAFT ENDS



No. 1

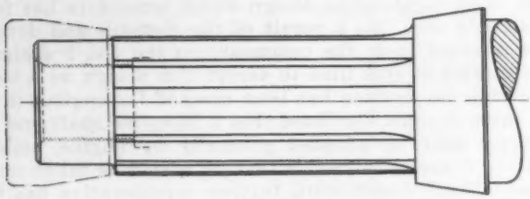
Taper				Key		
Length	Angle Included	Dia. at Small End	Dia. at Large End	Length	Width	Thickness
5 5/32	5 4 4″ 1.2 per ft.	1.535	2.05	3	3/8	¼



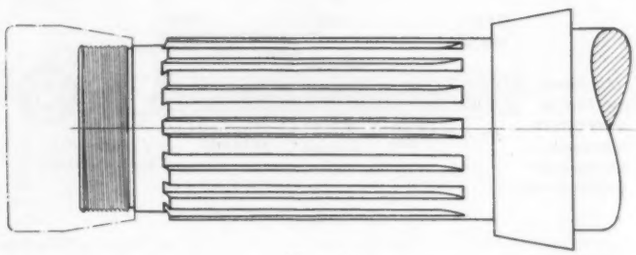
No. 2

Taper				Key		
Length	Angle Included	Dia. at Small End	Dia. at Large End	Length	Width	Thickness
7	5°4′4″ 12″ per ft.	1.662	2.362	5½	0.472	¼

PROPELLER-HUB SHAFT ENDS



No. 3



No. 4

Splines					Cone		
Length Effective	Width	Large Dia.	Small Dia.	No.	Length	Angle Included	Large Dia.
4 5/16	0.500	2.495	2.219	8	1 1/4	17°	3.1875

Splines					Cone		
Length Effective	Width	Large Dia.	Small Dia.	No.	Length	Angle Included	Large Dia.
4 1/4	0.304	3.125	2.875	16	1 1/8	30°	3.875

Note: The propeller-shaft dimensions tabulated above are limited to those dimensions necessary to assure interchangeability of propeller-hubs in large sizes. Propeller-hub retaining means have not been included in the specifications, since considerable variations exist in present practice as to type of nut and thread, which features do not effect the interchangeability of the propeller-hubs.

GENERATOR MOUNTINGS

The Division recommends the approval of the following specification on generator-mounting dimensions as an S.A.E. Standard. This represents the general practice on virtually all generators and engines produced at present.

(*See upper cut on facing page*)

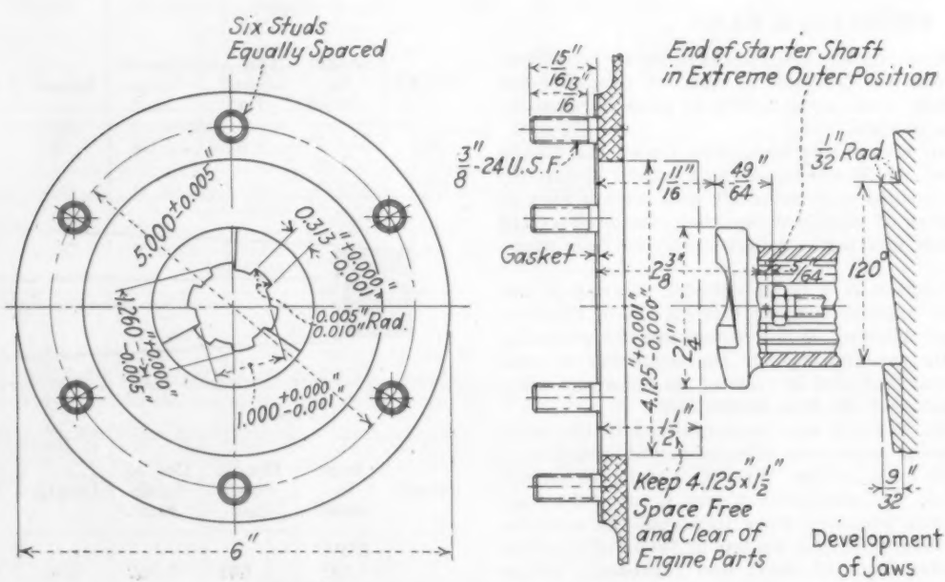
FUEL-PUMP MOUNTINGS

The Division recommends the approval of the following specification on fuel-pump mounting dimensions as an S.A.E. Standard. This represents the general practice on virtually all fuel-pump mountings at present.

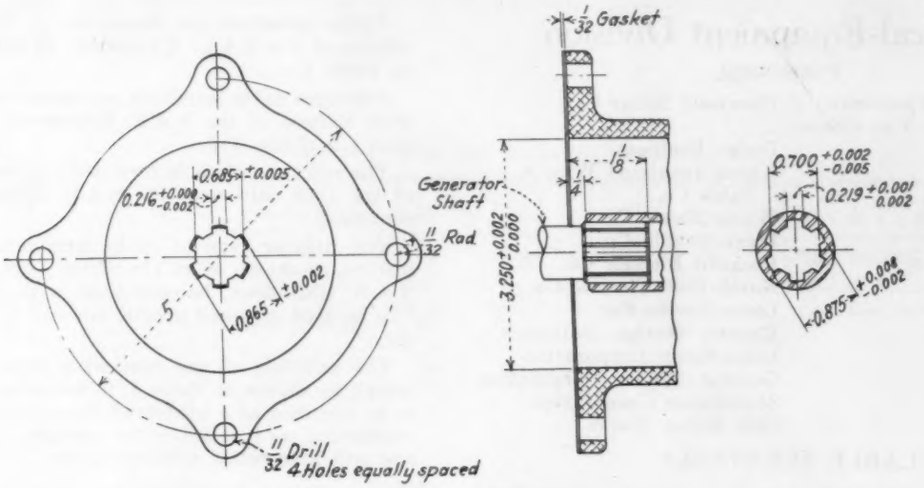
(*See central cut on facing page*)

ENGINE-STARTER MOUNTINGS

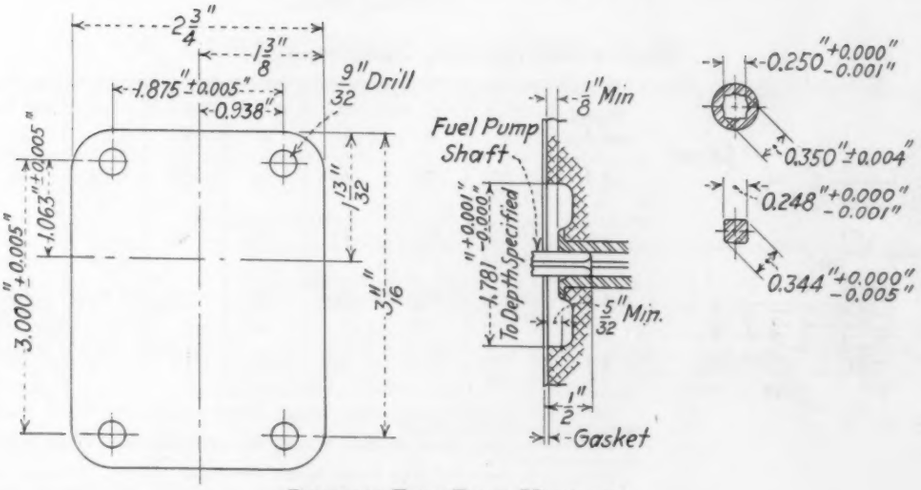
In present practice, engine starters have generally uniform mounting-flange dimensions, and consequently the Subdivision appointed to consider this subject formulated a report to the Aeronautic Division recommending the following dimensional specifications. While it is realized that improved designs may require additional mounting-dimension specifications for any new sizes that may be developed, it is felt that the proposed specifications cover the requirements at present. A Subdivision has been appointed to give this matter further consideration. In the meantime, the Division recommends that the Standards Committee approve the following specifications as an S.A.E. Standard:



PROPOSED ENGINE-STARTER MOUNTING



PROPOSED GENERATOR MOUNTING



PROPOSED FUEL-PUMP MOUNTING

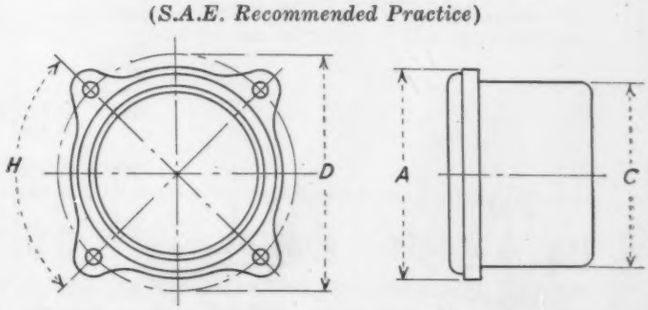
INSTRUMENT MOUNTINGS

Although the original Subdivision report, as presented by Chairman Black of the Aeronautic Division, recommended that no specifications on instrument mountings be approved at this time, it was the Division's opinion, as expressed by those at the meeting on April 18, that some dimensions should be provided for mounting instruments, as general dimensions are almost identical. Therefore, it was recommended that mounting dimensions for altimeters, air-speed indicators, tachometers, pressure-gages and thermometers be approved as S.A.E. Recommended Practice, such dimensions to apply only to mounting holes and bolt spacings, it being understood that the Subdivision will continue its effort to standardize the general dimensions and connections on the various makes of each type of instrument.

The following specification is recommended for approval as an S.A.E. Recommended Practice:

AERONAUTIC INSTRUMENT MOUNTINGS

(S.A.E. Recommended Practice)



Instrument	*A*	*C* Max.	*C*	*H*
Tachometer	4¾	4⁹⁄₆₄	4¾	90 deg.
Air-Speed Indicator	.—	3.9	4⁹⁄₁₆	90 deg.
Temperature Gages	3⅛	2⁵⁄₁₆	2¹³⁄₁₆	120 deg.
Altimeter	4½	3⁵⁄₁₆	4⁷⁄₆₄	90 deg.

Electrical-Equipment Division

PERSONNEL

A. R. Lewellen, *Chairman*	Chevrolet Motor Co.
D. M. Pierson, *Vice-Chairman*	Dodge Brothers
Azel Ames	Kerite Insulated Wire & Cable Co.
A. K. Brumbaugh	White Motor Co.
D. S. Cole	Leece-Neville Co.
W. S. Haggott	Packard Electric Co.
T. L. Lee	North East Electric Co.
B. M. Leece	Leece-Neville Co.
L. E. Lighton	Electric Storage Battery Co.
F. H. Prescott	Delco-Remy Corporation
B. M. Smarr	General Motors Corporation
T. E. Wagar	Studebaker Corporation
J. C. Wood	Olds Motor Works

CABLE TERMINALS

Herewith is quoted that part of the report of the Subdivision on Cable Terminals dealing with the proposed revision of present S.A.E. Specifications. It is recommended that:

Cable terminals, as shown on p. 115 of the 1928 edition of the S.A.E. HANDBOOK, be revised as shown in Table 1.

Side-type cable terminals, as shown on p. 116 of the 1928 Edition of the S.A.E. HANDBOOK, be revised as shown in Table 2.

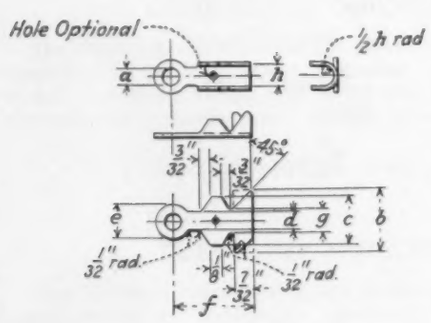
The roll type of cable terminals, as shown on p. 117 of the 1928 edition of the S.A.E. HANDBOOK, be discontinued.

The tubular type of cable terminals for starting-motors, as shown on p. 118 of the 1928 edition of the S.A.E. HANDBOOK, be continued, with the note added "To be used on small production and for service work only."

The addition of the open-wing type of cable terminal, as shown in Table 3, is recommended. This is to be specified as a preferred design and for quantity production, as it is better for assembly and inspection and will give better soldered joints.

These revisions have been approved by the Electrical-Equipment Division and are recommended to the Standards Committee for approval in accordance with the following revised tables:

TABLE 1—STRAIGHT-TYPE CABLE TERMINALS



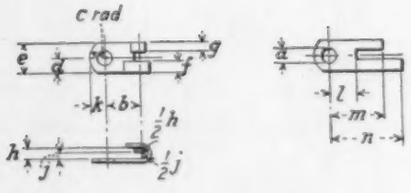
Terminal No.	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	Thickness
A 1	0.190 0.195	21/32	1/2	3/16	11/32	13/16	1/4	7/32	1/32
A 2	0.253 0.258	25/32	5/8	1/4	9/16	7/8	7/16	1/4	1/32
A 3	0.320 0.325	25/32	5/8	1/4	5/8	7/8	7/16	1/4	1/32
A 4	0.400 0.406	25/32	5/8	5/16	11/16	7/8	7/16	1/4	0.040

Alternate Construction.—The wings which clamp the cable may be cut square as indicated by dotted lines.

Material.—Soft sheet copper, S.A.E. Specification No. 71 or soft sheet brass S.A.E. Specification No. 70.

Terminals shall be free from burrs, corrosion or any foreign matter. The temper of the terminals shall be sufficiently soft to permit the terminal being assembled with the wings closed and without fracture or cracks in the terminal, which would impair the strength of the assembly.

TABLE 2—SIDE-TYPE CABLE TERMINALS



Terminal No.	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*j*	*k*	*l*	*m*	*n*	Thickness
B 1	0.125 0.128	11/32	3/16	5/32	5/16	1/8	3/32	7/64	1/16	5/32	9/32	9/16	3/4	1/32
B 2	0.190 0.195	9/32	7/32	3/16	3/8	5/32	1/8	5/32	5/64	3/16	1/4	35/64	21/32	1/32
B 3	0.190 0.195	11/32	7/32	3/16	3/8	5/32	1/8	7/32	1/8	3/16	5/16	47/64	15/16	1/32
B 4	0.190 0.195	13/32	7/32	3/16	3/8	5/32	1/8	5/32	5/64	3/16	3/8	43/64	25/32	1/32
B 5	0.253 0.258	9/16	5/16	1/4	1/2	3/16	7/32	9/32	7/32	1/4	1/2	1 3/16	1 5/16	0.040
B 6	0.320 0.325	9/16	1/2	3/8	3/4	5/16	11/32	9/32	7/32	3/8	1/2	1 3/16	1 5/16	0.040
B 7	0.400 0.406	9/16	1/2	3/8	3/4	5/16	11/32	9/32	7/32	3/8	1/2	1 3/16	1 5/16	0.040

Material.—Soft sheet copper, S.A.E. Specification No. 71, or soft sheet brass, S.A.E. Specification No. 70.

Terminals shall be free from burrs, corrosion or any foreign matter. The temper of the terminals shall be sufficiently soft to permit the terminal being assembled with the wings closed and without fracture or cracks in the terminal, which would impair the strength of the assembly.

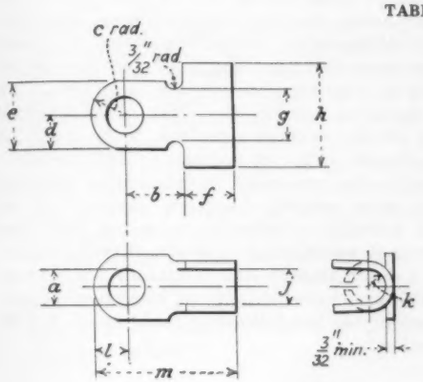


TABLE 3—STRAIGHT TYPE FOR STARTING MOTORS

Terminal No.	Wire Size	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*j*	*k*	*l*	*m*
T	1	13/32	21/32	13/32	3/8	3/4	9/16	19/32	1 3/16	13/32	11/64	3/8	1 19/32

Material.—Soft sheet copper, S.A.E. Specification No. 71, or soft sheet brass, S.A.E. Specification No. 70.

CABLE, CONDUIT AND TUBING CLIPS

The Division recommends the revision of the present S.A.E. Specifications on Cable, Conduit and Tubing Clips, p. 119 of the 1928 edition of the S.A.E. HANDBOOK, in accordance with Table 4.

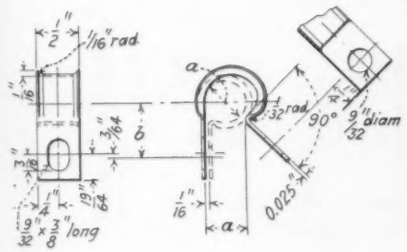


TABLE 4—CABLE, CONDUIT AND TUBING CLIPS

a	Diameter	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
b	Length	15/32	1/2	17/32	9/16	19/32	5/8	21/32	11/16	3/4	13/16	7/8

Material.—S.A.E. No. 10 Steel or equivalent, cold-rolled dead-soft.
Clips shall be made to full lines, as shown above, and bent to dotted lines when assembling. They must be free from burrs and sharp edges.

FLEXIBLE-CONDUIT FERRULES

This subject was referred to the Subdivision on Cable Terminals for the development of dimensional specifications for this item. The Subdivision's report was approved by the Division, which recommends the adoption of the specifications shown in Table 5 as an S.A.E. Standard.

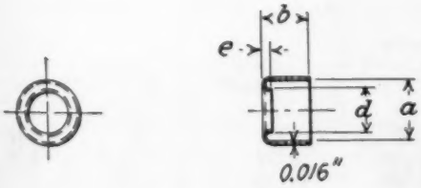


TABLE 5—FLEXIBLE-CONDUIT FERRULES

	Conduit Diameter	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1	1 1/4
a	Inside Diameter	0.285	0.355	0.425	0.485	0.555	0.630	0.760	0.930	1.040	1.175	1.435
b	Length	1/4	1/4	1/4	3/8	3/8	3/8	1/2	1/2	1/2	5/8	5/8
d	Shoulder Diameter	0.188	0.250	0.313	0.375	0.438	0.500	0.625	0.750	0.875	1.000	1.250
e	Shoulder	1/16	1/16	1/16	1/16	1/16	1/16	3/32	3/32	3/32	1/8	1/8

Material.—Soft sheet brass, S.A.E. Specification No. 70, or S.A.E. No. 1010 dead-soft sheet steel.
All steel ferrules must be zinc or cadmium-plated to withstand salt-spray test for 24 hr. without showing rust.

Engine Division

PERSONNEL

A. F. Milbrath, *Chairman*	Wisconsin Motor Mfg. Co.
E. S. Marks, *Vice-Chairman*	H. H. Franklin Mfg. Co.
Paul Bastien	Stutz Motor Car Co.
H. C. Blake	Foos Gas Engine Co.
R. J. Boege	The Buda Co.
C. L. Cummins	Cummins Engine Co.
J. B. Fisher	Waukesha Motor Co.
J. D. Harris	McCord Radiator & Mfg. Co.
E. D. Herrick	Lycoming Mfg. Co.
C. B. Jahnke	Fairbanks, Morse & Co.
E. T. Larkin	Sterling Engine Co.
K. R. Manville	International Motor Co.
F. W. Sampson	Continental Motors Corporation
L. P. Saunders	Harrison Radiator Corporation
A. W. Scarratt	International Harvester Co.

DUPLEX-CARBURETER FLANGES

Concurrently with the application of duplex carbureters, particularly to eight-cylinder engines, a demand arose for the standardizing of a mounting flange for this type of carbureter, and a Subdivision was appointed to study present designs and proposed flanges.

Following the general line of the existing duplex-carbureter flanges, an optional four or six-bolt design was devised and agreed to by all interested carbureter manufacturers. The difficulties due to insufficiency of bolt and wrench clearances have been obviated by moving the bolt-holes outward from the barrels. Consideration was given also to the barrel spacing.

In the design and sizes proposed the barrel diameters conform to the present S.A.E. Standards for single carbureters.

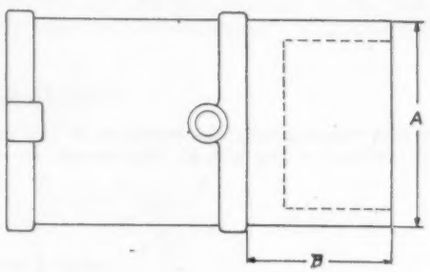
The Division recommends that the following design and dimensions of duplex-carbureter flanges be approved by the Standards Committee as S.A.E. Recommended Practice:

AIR-CLEANER MOUNTINGS

A Subdivision has developed a series of dimensions for the open-end of air-horns to provide standard sizes for the mounting of air-cleaners. The dimensions proposed are the outside diameter and the length of the portion of the air-horn on which the air-cleaners are mounted. No attempt has been made to specify the sizes of carbureter on which air-horns of the various sizes are to be used, as carbureter manufacturers differ in opinion on this point.

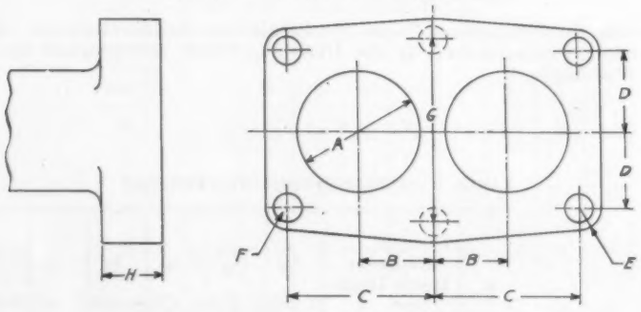
The sizes included in the proposed recommended practice represent the sizes most widely used on carbureters of various makes and provide a suitable range of sizes for air-cleaner attachments permitting manufacturers of air-cleaners to provide for a standard line of clamps for attachments, in place of the great multiplicity of sizes now in use.

The Division recommends the following table as an S.A.E. Recommended Practice:



A	B
0.750-0.740	5/8
1.125-1.115	3/4
1.500-1.490	7/8
1.624-1.614	7/8
1.812-1.802	3/4
2.062-2.052	1
2.312-2.302	1 1/8
2.625-2.615	1 1/2
3.125-3.115	1 3/4

DUPLEX-CARBURETER FLANGES



Nominal Carbureter Size, In.	A	B	C	D	E	F	G	H
1	1 3/16	23/32	1 1/2	13/16	5/16	9/32	1 7/8	3/8
1 1/4	1 7/16	13/16	1 5/8	15/16	23/64	11/32	2 1/8	7/16
1 1/2	1 11/16	15/16	1 27/32	1	23/64	11/32	2 3/16	7/16
1 3/4	1 15/16	1 1/16	2 1/16	1 1/4	25/64	13/32	2 3/4	1/2
2	2 3/16	1 3/16	2 3/8	1 7/32	25/64	13/32	2 11/16	9/16

Six-bolt flanges are optional on the 1, 1¼ and 1½-in. sizes but are recommended for use as necessary on the 1¾ and 2-in. sizes.

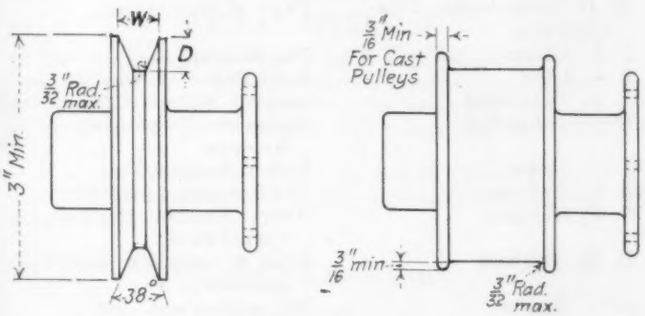
FANS, BELTS AND PULLEYS

The original report of the Division presented to the Standards Committee in January was turned back to the Engine Division for further consideration of the angle of the belt. The Division at its last meeting, on May 10, fully discussed this point and the report of the Subdivision, which had again taken the matter under consideration. It was decided that, notwithstanding that a few large users prefer the 28-deg. angle for belts, the best practice, as well as the greatest use in practice, is the 38-deg. angle. Consequently the specifications are resubmitted as originally presented. Those companies which at present use the 28-deg. design have sufficiently large production to avoid any penalty in the way of a higher price and their requirements should be regarded as special.

The Division further recommends that the following revision of the present S.A.E. Specifications on Fan Belts and Pulleys, as presented to the Standards Committee in January, be resubmitted with a change, for approval as S.A.E. Standard.

Fan Belts and Pulleys

(S.A.E. Standard)



Note: Driving pulleys for flat belts shall be crowned and without flanges.

V-FAN BELT AND PULLEY DIMENSIONS

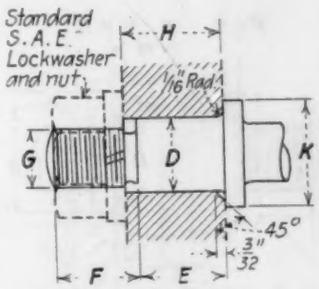
Width of V-Groove at Top, In. *W*	Minimum Depth of Groove, In. *D*	Maximum Fan Diameters Inclusive, In.	Maximum Projected Blade-Width, In.
5/8	9/16	Up to 14	1 5/8
5/8	9/16	15 to 18	1 7/8
3/4	11/16	19 to 20	2 1/4
1	15/16	21 to 22	2 1/2
1 1/4	1 1/8	23 to 26	2 1/2

Note: For heavy industrial service, twin belts are recommended on fans 26 in. in diameter or larger instead of one wide belt.

FLAT FAN-BELT AND PULLEY DIMENSIONS

Belt Width, In. ±1/32	Pulley Width, In. ±0.01	Maximum Fan-Diameter, Inclusive, In.	Maximum Projected Blade-Width, In.
1	1 1/8	Up to 14	1 5/8
1 1/4	1 3/8	15 to 18	1 7/8
1 1/2	1 3/4	19 to 20	2
2	2 1/4	20 to 22	2 1/4
2 1/2	2 3/4	21 to 24	2 1/2
3	3 1/4	25 to 28	2 1/2
3 1/2	3 3/4	29 to 36	3

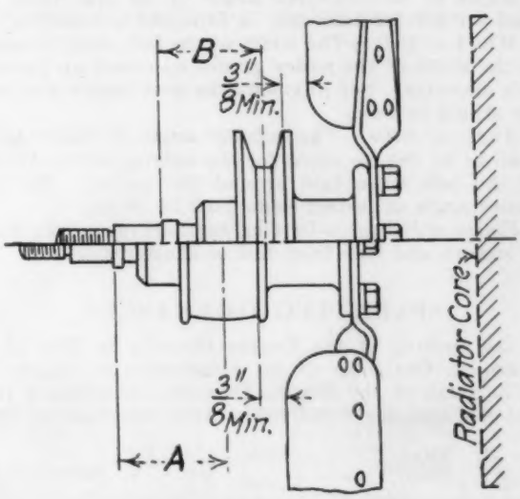
Length of slot to allow for ½-in. take-up per foot of belt length.



FAN-PULLEY SPINDLES FOR SLOTTED FAN-BRACKETS

Width of Belt, In.	*D*	*E*	*F*	*G*	*H*	*K*
1–1 1/4	0.748 0.746	7/8	7/8	5/8–18	1	1
1 1/2	0.873 0.871	1	7/8	5/8–18	1 1/8	1 1/8
2	0.998 0.996	1 3/8	15/16	3/4–16	1 5/8	1 1/4
2 1/2–3 1/2	1.248 1.246	1 9/16	1 5/16	1–14	2	1 1/2

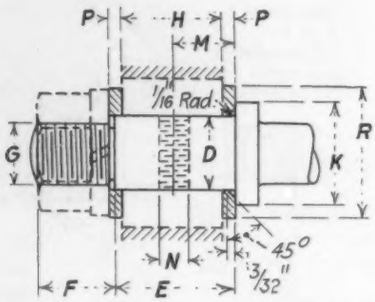
Pulley Diameters.—To ensure long belt-life, diameter of fan driven-pulley should be made as large as possible consistent with size of fan. Recommended diameter of fan driven-pulleys not less than one-fifth



FLAT AND V-BELT FAN-ASSEMBLY DIMENSIONS

Belt Widths, In.		*A*	*B*
Flat	*V*		
...	5/8	...	1 1/2
...	3/4	...	1 3/4
1	1	1 3/4	2 1/8
1 1/4	1 1/4	1 3/4	2 1/8
1 1/2	...	1 3/4	...
2	...	2	...
2 1/2	...	2 1/2	...
3	...	2 1/2	...
3 1/2	...	2 3/4	...

Note: When no shroud is used, front edge of fan blade shall be not more than ¾ in. from core.



FAN-PULLEY SPINDLES FOR SLOTTED FAN-BRACKETS

Width of Belt, In.	1–1¼	1½–2	2½–3½
D	0.873 0.871	0.998 0.996	1.248 1.246
E	1 3/16	1 5/16	1 7/8
F	13/16	15/16	1¼
G	5/8–18	¾–16	1–14
H	1	1⅛	1½
K	1	1¼	1½
M	5/8	13/16	1
N	5/16–18	½–20	½–20
P	3/16	¼	¼
R	1 3/8	1¾	2

of the diameter of fan and not less than 3¼ in. in any case. Diameters of fan pulleys to be given in increments of not less than ¼ in.

Angle of Groove.—An angle of 38 deg. shall be used for driving fans only or fans and accessories.

Width of Belt.—The width of the belt shall be equal to the width of the pulley groove measured on its outside diameter. For link-belts the next larger size pulley should be used.

Angle of Belts.—The included angle of rubber belts shall be 42 deg. to allow for the bulging of the inside of the belt when laid around the pulley. The included angle of leather belts shall be 38 deg.

Finish of Pulleys.—Driving surfaces of pulleys shall be smooth and free from tool or chatter marks.

SPARK-PLUG TOLERANCES

At the meeting of the Engine Division on May 10, Mr. Milbrath, as Chairman of the Subdivision on Spark-Plugs and Chairman of the Engine Division, submitted a report on the work of his Subdivision with reference to thread tolerances for S.A.E. Standard Spark-Plugs, p. 94 of the 1928 edition of the S.A.E. HANDBOOK.

The tolerances proposed were decided upon to provide a finger fit of the plug in the engine. The tolerances on the tapped hole are those provided in the S.A.E. Standard for Free-Fit Class 2 for Fine-Thread Series. The Division recommends that the present S.A.E. Standard for Spark-Plugs be revised by the addition of the tolerances shown in the tables at the foot of this page.

MOTORCYCLE SPARK-PLUGS

The present S.A.E. Specifications on Motorcycle Spark-Plugs and Metric Spark-Plugs, appearing on pp. 95 and 96 of the 1928 edition of the S.A.E. HANDBOOK, differ only in the thread tolerances where a variation of 0.001 to 0.003 in. occurs. In view of this the Subdivision and the Division recommend that the specifications for motorcycle spark-plugs be cancelled.

Iron and Steel Division

PERSONNEL

J. M. Watson, *Chairman*	Hupp Motor Car Corporation
A. H. D'Arcambal, *Vice-Chairman*	Pratt & Whitney Co.
J. R. Adams	The Midvale Co.
R. J. Allen	Rolls Royce of America, Inc.
A. L. Boegehold	General Motors Corporation
Henry Chandler	Vanadium Corporation of America
J. D. Cutter	Fafnir Bearing Co.
B. H. DeLong	The Carpenter Steel Co.
F. P. Gilligan	Henry Souther Engineering Corporation
H. W. Graham	Jones & Laughlin Steel Corporation
H. L. Greene	Willys-Overland, Inc.
W. G. Hildorf	Reo Motor Car Co.
E. J. Janitzky	Illinois Steel Co.
J. A. Mathews, Dr.	Crucible Steel Co. of America
W. C. Peterson	Snyder, New York City
E. A. Portz	Central Alloy Steel Corporation
S. P. Rockwell	Stanley P. Rockwell Co.
R. B. Schenck	Buick Motor Co.
W. R. Shimer	Bethlehem Steel Co.
Ralph R. Teetor	Perfect Circle Co.
H. P. Tiemann	Carnegie Steel Co.
E. W. Upham	Chrysler Corporation
T. H. Wickenden	International Nickel Co.
O. B. Zimmerman	International Harvester Co.

SPARK-PLUG THREAD TOLERANCES

Size	Threads per Inch	Major Diameter			Pitch Diameter			Maximum Minor-Diameter
		Maximum	Tolerance	Minimum	Maximum	Tolerance	Minimum	
⅞	18	0.8750	0.0082	0.8668	0.8384	0.0041	0.8343	0.8068

SPARK-PLUG TAPPED-HOLE TOLERANCES

Size	Threads per Inch	Minimum Major-Diameter	Pitch Diameter			Minor Diameter		
			Minimum	Tolerance	Maximum	Minimum	Tolerance	Maximum
⅞	18	0.8750	0.8389	0.0041	0.8430	0.8149	0.0060	0.8209

PHOSPHORUS AND SULPHUR CONTENT

After considerable investigation by a Subdivision, involving a survey of the practice of manufacturers and users of S.A.E. Steels, on the question of the sulphur and phosphorus limits of these steels and the percentage of rejections for steels not meeting these limits, the subject was presented to the Division at a meeting in Bethlehem on April 26 and 27. Considerable discussion ensued, it being the consensus of opinion that the sulphur limits of S.A.E. Carbon and Alloy Steels could be raised 0.005 without appreciably affecting the steel and without any effect whatever on the product of the user. It was voted to make no change in the phosphorus limits. It was further decided to add a note with reference to the possibility of obtaining low limits of sulphur and phosphorus when purchasing electric-furnace steels.

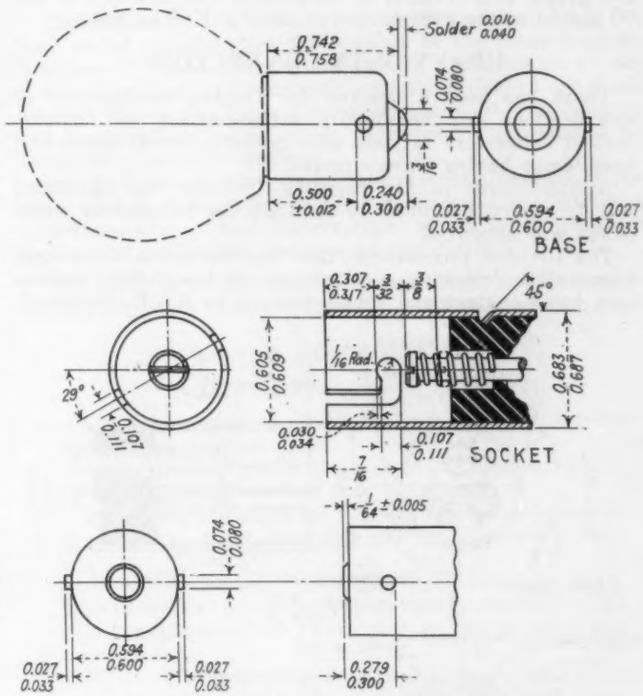
Therefore, the Division recommends for approval by the Standards Committee

> That the sulphur limits of all S.A.E. Carbon and Alloy Steels be raised 0.005 and a note added on the pages containing the steel specifications as follows: "Lower limits on sulphur and phosphorus can be obtained in electric-furnace steels at the option of the purchaser."

NICKEL STEELS

So that the manganese limits of S.A.E. Steels 6120 and 2320 shall be in line with the manganese limits of similar steels, the Division at its last meeting, on April 26, voted to recommend to the Standards Committee the following revision:

> That the manganese limits on S.A.E. Steels 6120 and 2320 be changed from 0.50 to 0.80 to 0.30 to 0.60.



PROPOSED SINGLE-CONTACT SOCKET AND BASE

Lighting Division

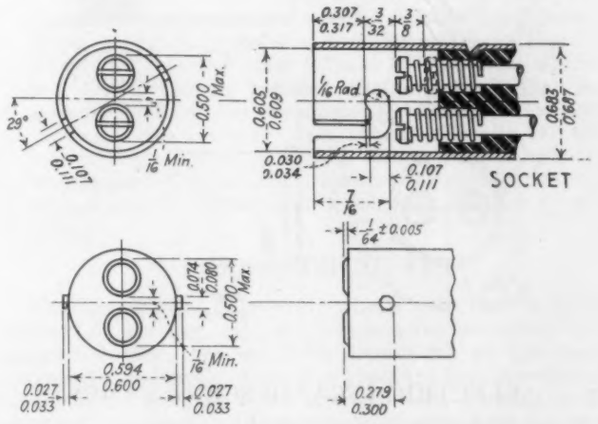
PERSONNEL

C. A. Michel, *Chairman*	Guide Motor Lamp Mfg. Co.
R. N. Falge, *Vice-Chairman*	General Motors Corporation
C. C. Bohner	Tung-Sol Lamp Works
H. S. Broadbent	Westinghouse Lamp Co.
R. E. Carlson	Edison Lamp Works, General Electric Co.
A. W. Devine	Commonwealth of Massachusetts
H. C. Doane	Buick Motor Co.
P. J. Kent	Chrysler Corporation
A. R. Lewellen	Chevrolet Motor Co.
H. H. Magdsick	National Lamp Works
Walter Spear	Cincinnati Victor Co.
W. F. Thoms	Indiana Lamp Corporation
T. E. Wagar	Studebaker Corporation of America

INCANDESCENT-LAMP BASES AND SOCKETS

To provide more accurate focusing, considerable demand has developed for the reduction of the tolerances on incandescent-lamp bases and socket diameters. It has been contended that the loose fit between lamps and sockets has rendered accurate focusing impossible in many cases. Conversely, tight fits between sockets and bases have been responsible for a large amount of lamp breakage when inserting bulbs in sockets at the time of assembling.

This has been of great concern to the Lighting Division and has been thoroughly studied in cooperation with the lamp-base and socket manufacturers. As a result, it has been found possible to reduce the tolerances. Also, to assure the proper length of throw of the spring pins in the sockets, some additional dimensions on the J slot are proposed. A new dimension from the top of the pin to the open end of incandescent-lamp bases is also proposed. The



PROPOSED DOUBLE-CONTACT SOCKET AND BASE

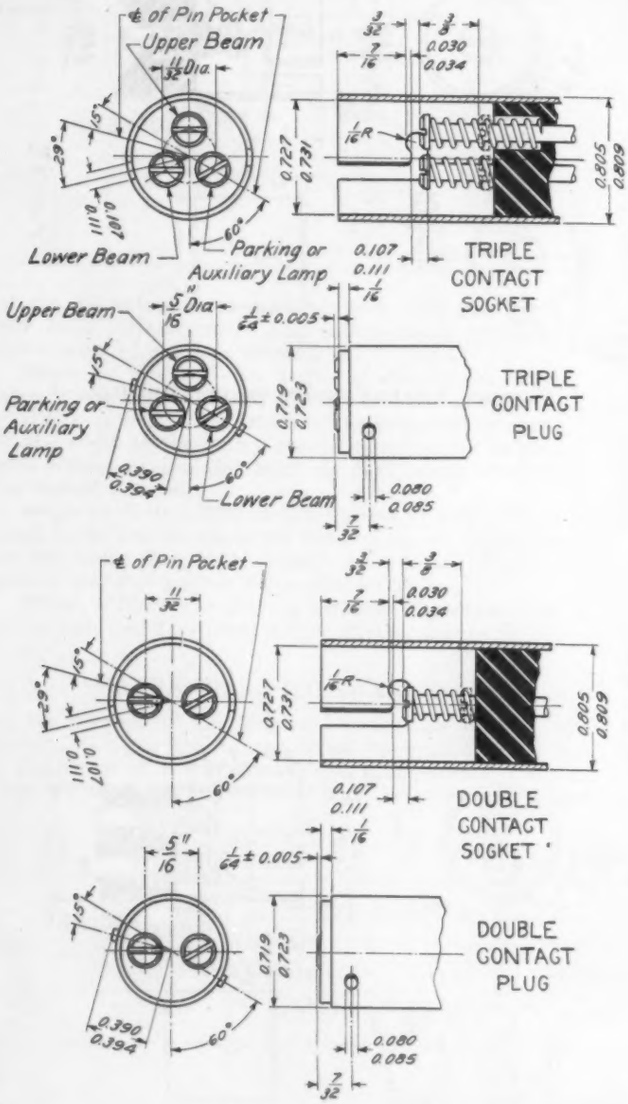
accompanying illustrations give the proposed tolerance reductions and the new dimensions for single-contact bases, sockets and plugs, and for double-contact bases, sockets and plugs, as a revision of the present specifications on pp. 90 and 91 of the 1928 edition of the S.A.E. HANDBOOK.

HEAVY-DUTY CONNECTORS

There has been a demand for further development of specifications for heavy-duty triple-contact and double-contact connectors for use with multiple signal-lamps and head-lamps having three circuits.

A Subdivision of the Lighting Division was appointed and its report, submitted to the Lighting Division by letter ballot, was approved.

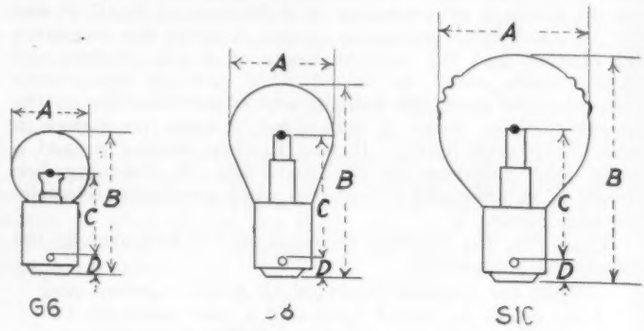
The Division recommends that the Standards Committee approve the following specifications on heavy-duty connectors, triple-contact and double-contact, as S.A.E. Standard.



ELECTRIC INCANDESCENT LAMPS

To conform to present manufacturing practice it is necessary to revise the table printed as General Information, on p. 89 of the 1928 edition of the S.A.E. HANDBOOK, under the heading of Electric Incandescent Lamp Data by changing the bulb type on the 6-cp. 6-8-volt lamp from G8 to G6 and the bulb type on all 21 and 32-cp. lamps from S11 to S10. This necessitates eliminating the bulb dimensions for the S11 type and substituting the S10 dimensions as a revision of the drawing and table on p. 88 of the 1928 edition of the S.A.E. HANDBOOK.

The Division recommends that the electric incandescent-lamp specifications be revised to read as follows:



ELECTRIC INCANDESCENT LAMPS

Dimension	G-6	G-8	S-8	G-10	S-10[a]
A	3/4	1	1	1-1/4	1-1/4
B	1-7/16	1-3/4	2	2-1/8	2-3/16
C[1]	3/4	7/8	1-1/8	1-1/8	1-1/8
D Max.	0.300	0.300	0.300	0.300	0.300

[a] The corrugations on electric incandescent lamps for headlight service shall be sufficient depth to break up the filament image.

The spacing between the filaments of the depressed-beam or two-filament type of incandescent lamp shall be 0.140 in. ± 0.016 in.

[1] Light-center length and axial alignment tolerances for headlight lamps are ± 3/64 in.

ELECTRIC INCANDESCENT LAMP DATA
General Information

Candle-Power	Voltage	Maximum Amperage[2]	Bayonet-Base Contact[3]	Bulb Type	Bulb Diameter, In.	Maximum Overall Length, In.	Light-Center Length, In.	Filament Form[4]
2	3–4	1.00	S or D	G-6	3/4	17/16	3/4	C-2
3	6–8	0.75	S or D	G-6	3/4	17/16	3/4	C-2
3	12–16	0.50	S or D	G-6	3/4	17/16	3/4	C-2
3	18–24	0.25	S or D	G-6	3/4	17/16	3/4	C-2
6	6–8	1.25	S or D	G-6	1	1 3/4	7/8	C-2
6	12–16	0.75	S or D	G-8	1	1 3/4	7/8	C-2
6	40–44	0.25	D	G-10	1 1/4	2 1/8	1 1/8	C-5
15	6–8	2.00	S or D	S-8	1	2	1 1/8	C-2
15	12–16	1.25	S or D	S-8	1	2	1 1/8	C-2
21	6–8	3.00	D	S-10	1 3/8	2 3/8	1 1/4	C-2
21		3.00					1 1/4	C-2
21	6–8	3.00	S or D	S-10	1 3/8	2 3/8	1 1/4	C-2
21	12–16	1.50	S or D	S-10	1 3/8	2 3/8	1 1/4	C-2
21	40–44	0.50	D	S-10	1 3/8	2 3/8	1 1/4	C-13
21	6–8	3.00	D	S-10	1 3/8	2 3/8	1 1/4	C-2
2		0.75		S-10	1 3/8	2 3/8		C-12
27	18–24	1.25	D	S-10	1 3/8	2 3/8	1 1/4	C-2
32	6–8	4.00	S or D	S-10	1 3/8	2 3/8	1 1/4	C-2
32	12–16	2.00	S or D	S-10	1 3/8	2 3/8	1 1/4	C-2

[2] Improvements in lamp design and manufacture from time to time make possible changes in ampere ratings. The figures given are therefore maximum and are for use in calculating wire sizes and battery capacities. For test purposes the exact amperage should be obtained from the lamp manufacturer.

[3] S—Single-contact. D—Double-contact.

[4] C indicates a coiled-wire filament.

Lubricants Division

PERSONNEL.

E. W. Upham, *Chairman*	Chrysler Corporation
H. C. Mougey, *Vice-Chairman*	General Motors Corporation
Sydney Bevin	Tide Water Oil Co.
O. E. Eckert	Mid-Continent Petroleum Corporation
J. B. Fisher	Waukesha Motor Co.
J. C. Geniesse	Atlantic Refining Co.
W. H. Graves	Packard Motor Car Co.
W. S. James	Studebaker Corporation of America
C. M. Larson	Sinclair Refining Co.

K. G. Mackenzie	The Texas Co.
H. J. Saladin	Standard Oil Co. of Indiana
F. D. Shields	Transcontinental Oil Co.
C. W. Simpson	White Motor Co.
H. G. Smith	Gulf Refining Co.
J. B. Terry	Standard Oil Co. of California
R. E. Wilson	Standard Oil Co. of Indiana

CRANKCASE LUBRICATING OILS

After the adoption and the widespread use of the S.A.E. Viscoscity Numbers for Crankcase Lubricating Oils, the question of the application of these numbers to prediluted oils was raised with reference to the state of the oil at which the Saybolt Universal Viscosity should be taken to determine under which of the S.A.E. Viscosity Numbers the oil should be classified.

A Subdivision appointed to consider this subject prepared the following note, which the Lubricants Division recommends be approved for addition to the present S.A.E. Recommended Practice on Crankcase Lubricating Oil Viscosity Numbers:

Note: In the case of a prediluted oil, S.A.E. Viscosity Numbers, by which the oil is classified, shall be determined by the viscosity of the undiluted oil.

Passenger-Car Division

PERSONNEL

G. L. McCain, *Chairman*	Dodge Brothers, Inc.
H. C. Snow, *Vice-Chairman*	Auburn Automobile Co.
R. S. Begg	Jordan Motor Car Co.
S. R. Castor	H. H. Franklin Mfg. Co.
L. A. Chaminade	Studebaker Corporation of America
G. A. Delaney	Graham-Paige Motors Corporation
W. T. Fishleigh	Ford Motor Co.
W. H. Graves	Packard Motor Car Co.
J. B. Judkins	J. B. Judkins Co.
E. H. Nollau	E. I. duPont de Nemours & Co.
Ivan Ornberg	Hupp Motor Car Corporation
G. W. Smith	Buick Motor Co.

CAR-FRAME NUMBERS

As a result of the replies received to a questionnaire on the usage of the present specifications on car-frame numbers, p. 321 of the 1928 edition of the S.A.E. HANDBOOK, it was found that frame construction prevents the use of a standard location for such a number and that the specification, as now constituted, is not used nor can it be revised so as to be of any value. The Division therefore recommends that the present S.A.E. Specification for Car-Frame Numbers be cancelled.

CAR-PERFORMANCE TESTS

The Division, in its meeting on April 20, discussed the summary of replies received to a survey on the usage of the S.A.E. Car-Performance Tests Specification, p. 507 of the 1928 edition of the S.A.E. HANDBOOK. The survey indicated that virtually no utilization was being made of these standard tests.

It is the Division's opinion that the differences in engineering opinion and in equipment available for making car-performance tests make it impracticable to use standard methods of procedure. A Subdivision has been appointed to study the possibilities of developing standard testing forms for use in car-performance tests.

The Division therefore recommends that the present S.A.E. Specification on Car-Performance Tests be cancelled.

PLATE GLASS

The Passenger-Car Division, at its meeting on April 20, took under consideration the revision of the present specifications on Plate Glass, p. 325 of the 1928 edition of the S.A.E. HANDBOOK. These specifications have been criticised because of the thickness tolerances which, it was brought out, were not in accord with the general requirements of automobile manufacturers.

On the basis of information received from several of the glass manufacturers, the Division has revised the thickness tolerances and omitted the reference to the sizes contained in the first sentence of the present specification.

The Division recommends that the present S.A.E. Specifications on Plate Glass be revised to read as follows:

PLATE GLASS

(*S.A.E. Recommended Practice*)

The glass producer should be furnished with a templet of the finished glass.

Only polished plate glass shall be used in windshields and front-quarter door windows.

Polished plate glass for windshields and passenger-car windows shall be of two grades: "Selected Glazing" and "Glazing."

"Selected Glazing" plate glass shall contain practically no visible imperfections under specified conditions of inspection. Very fine scattered seeds are permissible.

"Glazing" plate glass shall contain no other visible imperfections than a few scattered seeds and occasional faint strings or faint short finish-marks.

The thickness of plate glass shall be 7/32 in., with tolerances of plus and minus 1/16 in. with variations in individual plates of not more than 1/64 in.

The following definitions of the terms used in the above specifications are taken from the report of the committee on standards of plate glass organized by the Bureau of Standards:

Seeds.—Minute bubbles smaller than 0.015 in. diameter. These are visible only on close inspection, usually appearing as small specks, and are an inherent defect in the best quality of plate glass.

Strings.—Light, wavy, transparent lines on the surface, appearing as though a thread of glass had been partially incorporated into the sheet.

Short Finish.—Poor polish is lack of smoothness, an improperly finished surface which has the appearance of being slightly pitted and wavy when the surface is viewed by reflected light. These indentations, which are slight, have a polished surface rather than a ground surface, but the general effect is a slight dulling of the surface. Poor polish is usually caused by improper grinding. Spots on the surface where the fine grinding has not proceeded far enough to produce a smooth surface before polishing will not polish smooth.

STEERING-WHEEL TESTS

That purchasers of steering-wheels may have a suitable method of making tests for comparative purposes, it was suggested that the Standards Committee of the Society undertake the development of a standard test procedure for determining steering-wheel strength. As a result, a Subdivision was appointed to develop such procedure for consideration.

The following report was submitted by F. D. Pease, of the Studebaker Corporation of America, to the Passenger-Car Division at its meeting on April 20, which report was approved for submission to the Standards Committee.

The Division recommends the following new specification as an S.A.E. Recommended Practice:

STEERING-WHEEL TESTS

(*S.A.E. Recommended Practice*)

Static-Load Tests.—Each wheel should be placed in a Tinius Olsen or other suitable testing machine and the rim supported midway between spider arms on two steel blocks approximately 3 in. square diametrically opposite each other. The wheel may be placed either in the position as normally seen or upside down, as tests should be made with wheels in each position.

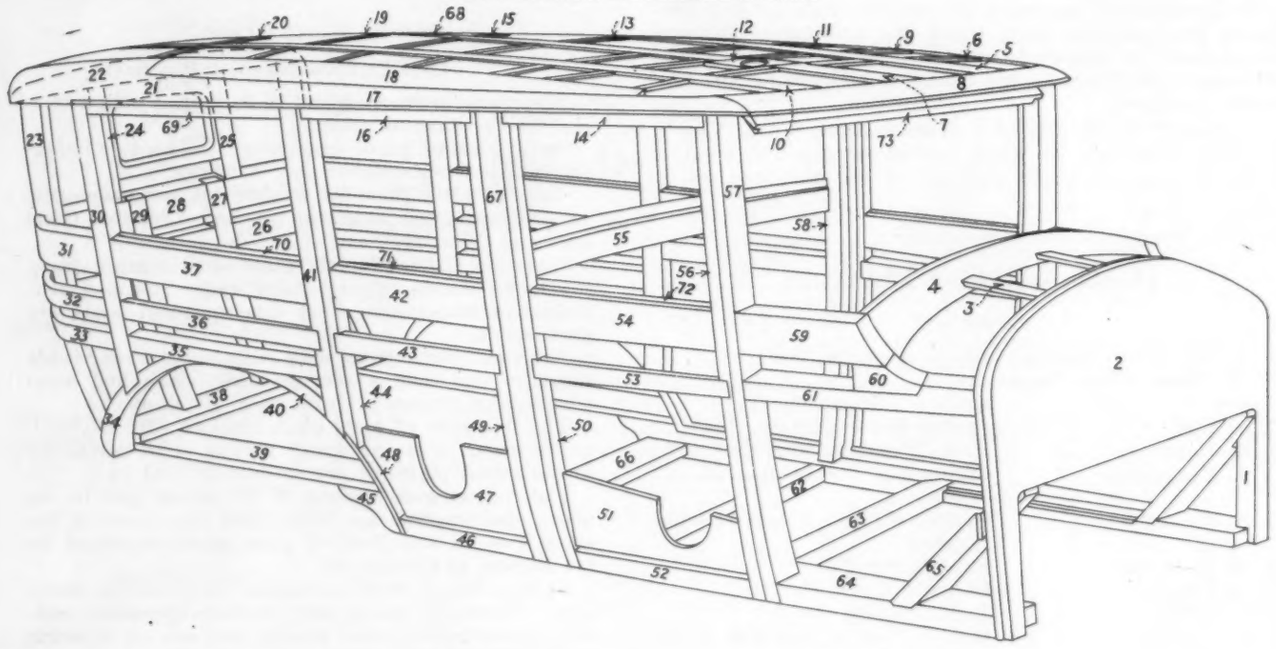
Load is applied uniformly and slowly downward through the hub until an initial failure occurs, which should be noted, and the loading continued until complete failure occurs. As previously mentioned, tests should be conducted with the wheel right side and bottom side up as viewed from the driver's seat.

Impact Tests.—Each wheel should be supported rigidly at the hub by means of a belt passing through the hub and a steel block clamped rigidly to the bed of a drop-hammer.

Impact is applied by means of a 20-lb. weight working freely in vertical guides. The weight is allowed to drop from a measured height and to fall on the rim midway between spider arms. The shock is cushioned by means of a piece of ⅜-in. pure para sheet rubber 4 x 5 in., which is clamped over the rim at the point of impact.

The distance which the weight is dropped to cause, (*a*) initial failure, (*b*) ultimate failure, and the characteristics of the failure should be noted. (*Next page.*)

BODY-PARTS NOMENCLATURE



Part No.	Name
1	Dash post
2	Dash
3	Cowl strainer
4	Cowl bar
5	Roof slat, left
6	Roof bow No. 1
7	Roof slat, center
8	Roof rail, front
9	Roof bow No. 2
10	Roof slat, right
11	Roof bow No. 3
12	Dome-light block, front
13	Roof bow No. 4
14	Front-door header bar
15	Roof bow No. 5
16	Rear-door header bar
17	Roof side-rail, right
18	Roof-rail filler
19	Roof bow No. 6
20	Roof bow No. 7
21	Back-light bar, upper
22	Rear roof-rail
23	Rear-corner pillar
24	Back-light strainer, right side
25	Back-light strainer, left side
26	Rear belt-rail, lower
27	Rear seat-strainer, left
28	Rear belt-rail, upper
29	Rear seat-strainer, right
30	Rear-quarter pillar
31	Rear-corner belt rail
32	Right rear-corner strainer, upper
33	Right rear-corner strainer, lower
34	Wheelhouse, rear
35	Wheelhouse, strainer
36	Rear-quarter strainer
37	Rear-quarter belt rail
38	Rear cross-rail
39	Kick-up sill
40	Wheelhouse, front
41	Rear-door body hinge pillar
42	Rear-door belt rail
43	Rear-door strainer
44	Rear-door hinge pillar
45	Kick-up filler block
46	Rear-door bottom bar
47	Rear-door bottom board
48	Rear-door hinge-pillar extension
49	Rear-door lock pillar
50	Front-door lock pillar
51	Front-door bottom board
52	Front-door bottom bar
53	Front-door strainer
54	Front-door belt rail
55	Front-door top rail
56	Front-door hinge pillar
57	Front-door body hinge pillar
58	Pillar partition, left
59	Cowl belt bar
60	Cowl belt-bar filler block
61	Cowl side strainer
62	Main-sill cross-bar No. 2
63	Main-sill cross-bar No. 1
64	Main sill, right
65	Toe-board riser
66	Main-sill cross-bar No. 3
67	Center body-pillar, right
68	Dome-light block, rear
69	Rear-quarter header bar
70	Rear-quarter regulator board
71	Rear-door regulator board
72	Front-door regulator board
73	Windshield header bar

As in the static load tests, wheels should be tested in two positions.

Determination of Moment of Inertia.—The pendulum method for determination of moment of inertia is used.

From Poorman's Applied Mechanics, Article 108, the radius of gyration of a compound pendulum is

$$K = T/2\pi\sqrt{gd}$$

where

T = time of one oscillation in seconds
g = acceleration of gravity
d = distance in feet from axis of rotation to a parallel centroidal axis.

Each wheel should be suspended on a knife edge from the inside of the rim and the time for 100 complete vibrations determined. From this the time T can be determined.

The distance d is measured from the point of suspension on the inside of the rim to the axis of rotation of the wheel. The weight of the wheel is determined in pounds:

Then, $I = I_o - md^2$ or, since $K = T/2\pi\sqrt{gd}$, and $I = M\ (K^2 - d^2)$,
$I = W/g\ [(T/2\pi)^2 (gd - d^2)]$

BODY-PARTS NOMENCLATURE

The demand for a standard body-parts nomenclature covering the various structural members of a typical body-frame led to the appointment of a Subdivision whose report was submitted on April 20 to the Passenger-Car Division for approval.

The Division recommends approval of the list of parts given on p. 718 as S.A.E. Standard.

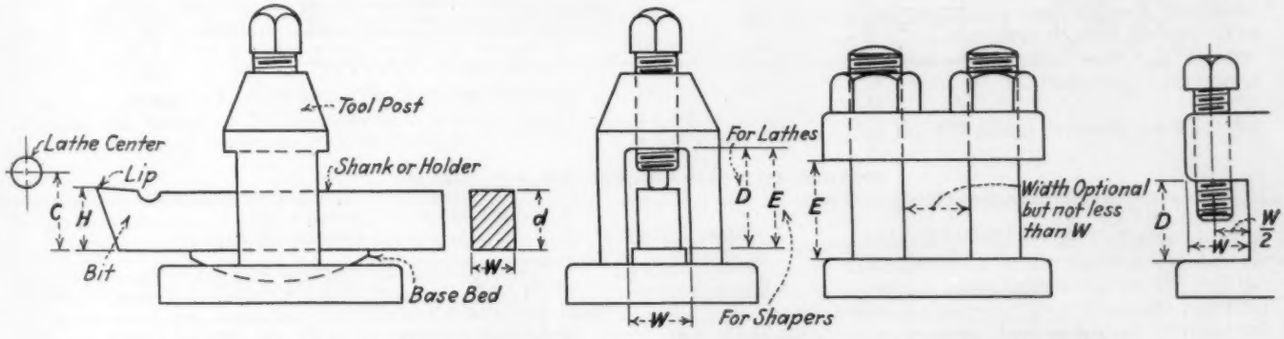
Production Division

PERSONNEL

L. F. Maurer, *Chairman*	Studebaker Corporation of America
F. W. Stein, *Vice-Chairman*	Fairbanks, Morse & Co.
David Ayr	Pratt & Whitney Co.
F. M. Bender	Lycoming Mfg. Co.
Joseph Berge	Crowner Co.
Eugene Bouton	Chandler - Cleveland Motors Corporation
R. A. DeVlieg	Chrysler Corporation
A. R. Fors	Continental Motors Corporation
H. P. Harrison	H. H. Franklin Mfg. Co.
O. C. Kavle	Manufacturers' Consulting Engineers
F. E. A. Klein	Pierce-Arrow Motor Car Co.
W. P. Michell	International Motor Co.
D. W. Ovaitt	Buick Motor Co.
E. N. Sawyer	Cleveland Tractor Co.
Wm. C. Thiel	Waukesha Motor Co.
E. K. Wennerlund	General Motors Corporation

TOOL-HOLDER SHANKS AND TOOL-POST OPENINGS

One of the first projects to be taken up by the Sectional Committee on Small Tools and Machine-Tool Elements that is sponsored by the Society, the American Society of Mechanical Engineers and the National Machine Tool Builders' Association under the procedure of the American Engineering Standards Committee, was Tool-Holder Shanks and Tool-Post Openings. At the meeting of this Committee in New York in March, 1926, Subcommittees were appointed



TOOL SHANKS, TOOL-POST OPENINGS, LATHE CENTER AND LIP-HEIGHTS

Tool No.	Tool-Shank Section			Lathe-Post Opening			Planer and Shaper Post-Opening			Lathe Center-Height C			Tool Lip Height H	
	$(d \times w)$ Nominal	d Maximum	w Maximum	$(D \times W)$ Nominal	D Minimum	W Minimum	$(E \times W)$ Nominal	E Minimum	W Minimum	Nominal	Maximum	Minimum	Maximum	Minimum
00	¾ x ⅜	0.85	0.40	1⅜ x ½	1.27	0.49	1 1/16 x ½	1.04	0.49	⅞	0.93	0.85	0.85	0.75
0	⅞ x 7/16	0.99	0.48	1½ x 9/16	1.48	0.57	1¼ x 9/16	1.19	0.57	1	1.09	0.99	0.99	0.87
1	1 x ½	1.15	0.56	1¾ x 11/16	1.72	0.68	1 7/16 x 11/16	1.38	0.68	1 3/16	1.26	1.15	1.15	1.00
2	1¼ x ⅝	1.34	0.67	2 x 13/16	2.00	0.81	1⅝ x 13/16	1.61	0.81	1⅜	1.47	1.34	1.34	1.25
3	1½ x ¾	1.56	0.80	2⅜ x 1	2.34	0.96	1⅞ x 1	1.87	0.96	1 9/16	1.72	1.56	1.56	1.50
4	1¾ x ⅞	1.81	0.95	2¾ x 1 3/16	2.71	1.14	2 3/16 x 1 3/16	2.17	1.14	1 13/16	1.99	1.81	1.81	1.75
5	2 x 1	2.11	1.13	3 1/16 x 1⅜	3.12	1.35	2 9/16 x 1⅜	2.53	1.35	2⅛	3.32	2.11	2.11	2.00
6	2¼ x 1¼	2.43	1.34	3 11/16 x 1⅝	3.65	1.61	2⅞ x 1⅝	2.82	1.61	2 7/16	2.67	2.43	2.43	2.25
7	2¾ x 1½	2.86	1.60	4¼ x 1⅞	4.12	1.87	3 7/16 x 1⅞	3.43	1.87	2⅞	3.15	2.86	2.86	2.75
8	3 x 1¾	3.34	1.90	5 x 2¼	5.00	2.25	4 x 2¼	4.00	2.25	3⅜	3.67	3.34	3.34	3.00
9	3½ x 2	3.87	2.26	5¾ x 2¾	5.75	2.70	4¾ x 2¾	4.64	2.70	3⅞	4.25	3.87	3.87	3.50
10	4¼ x 2½	4.50	2.69	6¾ x 3¼	6.75	3.21	5½ x 3¼	5.40	3.21	4½	4.96	4.50	4.50	4.25
11	5 x 3	5.25	3.20	7⅞ x 3⅞	7.87	3.84	6⅜ x 3⅞	6.30	3.84	5¼	5.77	5.25	5.25	5.00

that prepared the preliminary report printed on p. 572 of the May, 1927, issue of THE JOURNAL. The report was also circulated by the A.S.M.E. as the sponsor body responsible for the executive secretarial work of the Committee. The results of this circularization led to further consideration of the report by the Committee, which issued a final report in March of this year for approval.

The Production Division, at its meeting in Detroit on May 11, to which copies of the latter report had been sent, approved it with the recommendation that it be approved by the Society as a sponsor, for adoption as American Standard. The formal vote of approval by the Sectional Committee had not been taken before submitting the report to the sponsors for their approval but it was understood that this would be done shortly. The Production Division therefore now recommends approval of the report, subject to approval by the Sectional Committee, to avoid delaying final approval by the Society as a sponsor until the Annual Meeting next January. The report is not submitted for adoption by the Society as an S.A.E. specification.

When the tentative report was issued, definitions of terms were included. At the time of printing this report this question was still open and the definitions are printed herewith so that they may be approved for inclusion in the report should the Sectional Committee so decide.

TERMINOLOGY

Tool.—A non-adjustable cutting-device consisting of a bit and shank of the same forging, or a bit attached to the shank by welding. The device is restricted to the three general types adapted to lathes, planers and shapers.

Tool-Holder.—An adjustable cutting-device consisting of a replaceable bit clamped to the shank.

Bit.—The adjustable cutting-portion of the tool-holder, or the cutting portion of a solid tool.

Tool Base.—The plane of the shank which engages the tool bed.

Tool Bed.—The plane of the machine-tool against which the tool is clamped; the rocker of a lathe post.

Tool Post.—The slotted clevis-shaped clamp as regularly used on lathes and shapers.

Tool Clamp.—Any tool-holding device such as the openside clamp used on square turret-attachments to the lathe and the plate and cap-screw clamp used on planers.

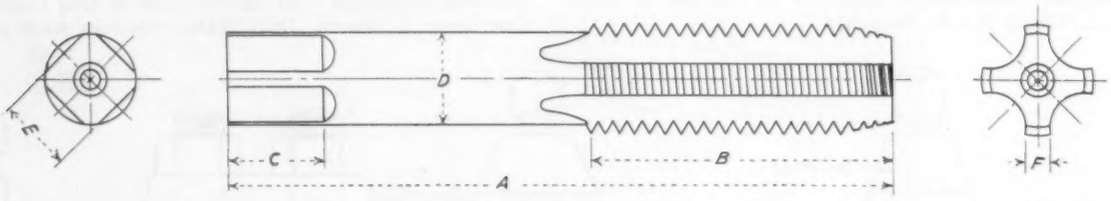
Width.—The transverse thickness of the tool shank or the slot width of the tool post.

Depth.—The transverse depth of the tool shank or the slot height above the bed of the tool.

Height.—The nominal distance from the tool base to the cutting-lip of the bit.

CUT AND GROUND TAPS

Since the adoption by the Society of the report on Taps with Cut and Ground Threads last July, an extension of the tap tables has been in preparation, which is expected to be acted upon under the procedure of the American Engineering Standards Committee by a Sectional Committee of which the Society is one of the sponsors. This extended report includes tables for cut and ground-nut taps in both the National coarse and National fine screw-thread pitches



STRAIGHT-PIPE TAPS—GROUND AND CUT THREADS

Size	Pitch Diameter				Major Diameter			General Dimensions					
	Basic	Minimum		Max.	Minimum		Max.	Over-all Length	Thread Length	Square Length	Shank Diam.	Square Size	Land Width
		Ground	Cut		Ground	Cut		*A*	*B*	*C*	*D*	*E*	*F*
1/16–27	0.3748	0.3690	0.3680	0.3700	0.3980	0.3975	0.3995	3 5/32	1 7/16	13/32	0.3230	0.2420	0.1020
1/4–18	0.4899	0.4820	0.4810	0.4830	0.5260	0.5255	0.5275	3 19/32	1 21/32	1/2	0.4290	0.3220	0.1360
3/8–18	0.6270	0.6190	0.6180	0.6200	0.6625	0.6625	0.6645	3 13/16	1 13/16	9/16	0.4800	0.3600	0.1720
1/2–14	0.7784	0.7680	0.7670	0.7695	0.8250	0.8245	0.8270	4 11/16	2 7/32	3/4	0.6970	0.5230	0.2000
3/4–14	0.9889	0.9785	0.9775	0.9800	1.0345	1.0345	1.0370	5 7/16	2 9/16	7/8	0.8960	0.6720	0.2500
1–11½	1.2386	1.2260	1.2245	1.2275	1.2945	1.2945	1.2970	5 3/4	2 9/16	1	1.0210	0.7660	0.2920

GENERAL SPECIFICATIONS

Pitch Diameter—Ground Thread
Maximum
Basic—2 threads
Minimum
1/8-1 inc. Max.—0.0010
1/4-1 inc. Max.—0.0015
Pitch Diameter—Cut Thread
Maximum
Basic—2 threads
Minimum
1/8-3/8 inc. Max.—0.0020
1/2-3/4 inc. Max.—0.0025
7/8-1 inc. Max.—0.0030
Major Diameter—Ground Thread
Maximum
1/8-1 inc. Max. pitch diam. + single thread depth
Minimum
1/4-1/4 inc. Max.—0.0015
3/8-1/2 inc. Max.—0.0020
1/4-1/2 inc. +0—0.0050
3/4-1 inc. +0—0.0070
Square Size-E
1/8 ±0.0040
1/4-1/2 inc. ±0.0060
3/4-1 inc. ±0.0080
Land Width-F
1/4-3/8 inc. Included angle 30 deg.
1/2-3/4 inc. Included angle 28 deg.
1 Included angle 26 deg.
1/4-1 inc. Size ±0.0100
Centers
Female
Number of Flutes
Four
Chamfer
3 to 5 threads
Marking
Minor Diameter
American (National) or sharper
3/4-1 inc. Max.—0.0025
Major Diameter—Cut Thread
Maximum
1/8-1 inc. Max. pitch diam. + single thread depth
Minimum
1/4-3/8 inc. Max.—0.0020
1/2-1 inc. Max.—0.0025
Overall Length-A
1/8-1 inc. ±1/32
Thread Length-B
1/8-1 inc. ±1/32
Square Length-C
1/8-3/8 inc. ±1/32
1/2-1 inc. ±1/16
Shank Diameter-D—Ground Thread
1/4-3/4 inc. +0—0.0015
7/8-1 inc. +0—0.0020
Shank Diameter-D—Cut Thread
Thread Angle—Ground Thread
Tolerance in 1/2 angle
Inclusive angle tolerance
Thread Angle-Cut Thread
Tolerance in 1/2 angle
11 1/2-27 thread ±45 min.
Inclusive angle tolerance
11 1/2-27 threads ±1 deg—8 min.
Lead Error—Ground Thread
±0.0005 per inch of thread
Lead Error—Cut Thread
±0.003 per inch of thread
Relief—Ground Thread
Back Taper 0.0005 to 0.0010 per inch
Slight eccentric relief permissible
Relief—Cut Thread
Back taper, manufacturer's Practice; slight eccentric relief permissible

and cut-pulley taps in the coarse series only. At the meeting of the Production Division of the Standards Committee at which these reports were considered, there was some question whether to include these tables in the S.A.E. Standard, as these taps are used very little by motor-vehicle manufacturers. It was indicated, however, that they are used to a considerable extent by automotive parts and accessory manufacturers and should be included in the report.

A table for straight-pipe taps with cut and ground threads has been developed by the Tap and Gage Committee of the General Motors Corporation in a manner similar to that of the tap tables originally developed and submitted to the Society last year. It is proposed to include this table also in the S.A.E. Production Standard. Since publication of the S.A.E. report last year, a few corrections in the report have been made.

At the meeting of the Production Division of the Standards Committee in Detroit on May 11, the additional tables and the corrections reported herewith were reviewed and recommended for adoption by the Society.

Taps, Cut and Ground Threads

(Revision of S.A.E. Standard)

In the general specifications following the tables of Machine-Screw Taps; Hand-Plug Taps-cut threads; and Tapper Taps-cut threads, pp. 1, 2 and 5 respectively of the S.A.E. report, the formula for the maximum major-diameter of cut threads should be corrected to read, basic plus $\sqrt{\frac{D}{100}}$.

In the table of Tapper Taps-ground threads, the basic pitch-diameter for the ⅞-14 size should be 0.8286 instead of 0.8268. The tolerance on the length of the square for the ¾ to 1½-in. sizes inclusive should be ± 3/64 instead of ± 1/16. The size of the square for the 9/16 to 1-in. sizes inclusive should be + 0 — 0.0060.

In the general specifications for Tapper Taps-cut threads, the tolerance for the length of square on the ¾ to 1½-in. sizes should be ± 3/64 instead of ± 1/16 in.

The following note should also be included relative to the marking of all taps referred to in the standard.

Note.—All taps shall be marked with a nominal size and pitch. They may be marked NF (National Fine) or NC (National Coarse) to distinguish them from other taps in use, especially during the transition in practice to the standard. It is recommended that no markings such as S.A.E., A.S.M.E. or N.S.T.C. be used on any taps.

CYLINDRICAL PLUG AND THREAD-GAGES

In November, 1926, a meeting was called by Col. J. O. Johnson, chief of the Gage Section of the Ordnance Department of the Army, in New York City, to consider the feasibility of standardizing the design of plain and threaded plug and ring-gages of the sizes most commonly used in interchangeable manufacture in order to ensure prompt and economical procurement of gages required by the Ordnance Department in time of National emergency. The Committee, as originally informally organized, was so broadly representative of manufacturers and industrial users of gages that it was believed the findings of the Committee might be of economic value to the industry as well as the Ordnance Department, and the work developed therefore along broader lines than was originally contemplated. The Committee has confined its work to the general design of gages, the details of finished gages being left to individual manufacturers.

The first report of this Committee was on cylindrical plug and thread-gages, formulated by a Technical Subcommittee of which D. W. Oviatt, who is a member of the S.A.E. Production Division, is chairman. Upon completion of this report it was referred to the Society, among others, for such action as might be deemed advisable. The subject was believed to be an appropriate one for standardization by the members of the Production Division and the report was subsequently referred to them for consideration for adoption as an S.A.E. specification. At the meeting of the Division in Detroit on May 11, it was recommended that the report be adopted as an S.A.E. Production Recommended Practice, including three additional small sizes for the cylindrical plug and handles. The dimensions for the additional sizes were not available, however, at the time of printing this report.

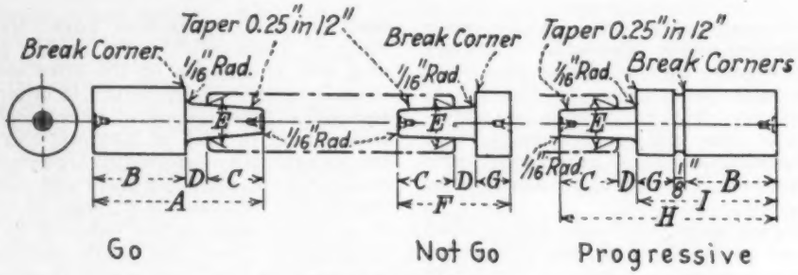
The regulations governing the Standards Committee of the Society permit the adoption of reports issued by other bodies provided they are acted upon within the Standards Committee in the same way as subjects originating within the Society. The policy of adopting such reports was referred to the Standardization Policy Committee. The members replying indicated their approval of such action. The report is therefore submitted for adoption as S.A.E. Recommended Practice to be published in pamphlet form as a production specification.

(*See pp.* 722 *and* 723 *for the tables forming part of this report.*)

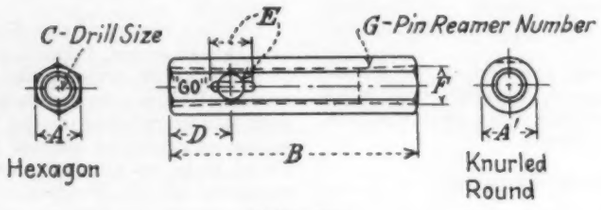
RING THREAD-GAGES

Shortly after the foregoing report on Cylindrical Plug and Thread-Gages was submitted to the Society, the American Gage-Design Committee completed work on the following report on Ring Thread-Gages. This was also referred to the Society and considered by the Production Division at its meeting in Detroit last May, at which it was recommended that the report be adopted as S.A.E. Recommended Practice and for publication with the other Production Standard specifications of the Society.

(*See pp.* 724 *and* 725 *for tables forming part of this report.*)



CYLINDRICAL PLUGS

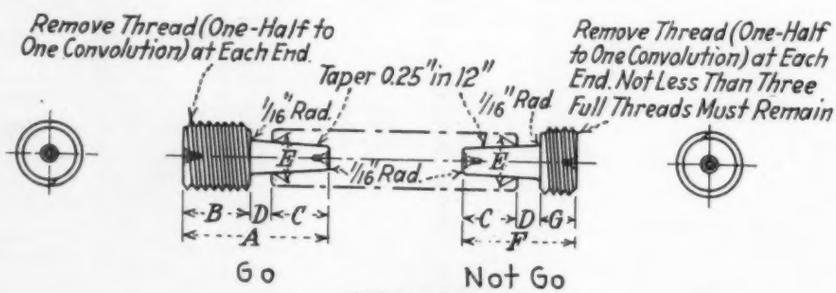


HANDLES

TABLE 1—PLUGS AND HANDLES

Handle Size	Cylindrical Plugs: Range		Go		All			Not Go		Progressive		Handles								Thread Plugs
	Above	Including	A	B	C	D	E	F	G	H	I	A	B	Drill C	D	E	F	G	A'	Inclusive
000																				
00																				
0																				
1	0.240	0.365	1¾	¾	¾	¼	0.239 0.240	1 5/16	5/16	2 3/16	1 3/16	⅜	2¾	7/32	25/32	⅛ x ½	0.239 0.240	#4	7/16	¼ to 5/16
2	0.365	0.510	2	1	¾	¼	0.309 0.310	1⅜	⅜	2½	1½	½	3	L (0.290)	25/32	15/64	0.309 0.310	#6	⅝	⅜ to ½
3	0.510	0.825	2¼	1¼	¾	¼	0.408 0.410	1½	½	2⅞	1⅞	11/16	3¼	25/64	27/32	11/32	0.409 0.410	#7	13/16	9/16 to ¾
4	0.825	1.135	2 9/16	1⅜	⅞	5/16	0.608 0.610	1 13/16	⅝	3 5/16	2⅛	⅞	3⅝	37/64	63/64	⅜	0.609 0.610	#10	1 1/16	⅞ to 1⅛
5	1.135 1.510	1.510 2.010	2⅞ Optional	1½	1 range.	⅜	0.808 0.810 See note.	2⅛	¾	3¾	2⅜	1⅛	4	29/32	1⅛	7/16	0.809 0.810	#11	1 5/16	1¼ to 1½

Note.—The optical range applies only for the Cylindrical Plug-Gages.
A shallow groove may be turned in the "Not-Go" end of the handle to identify it from the "Go" end.



THREAD GAGES

TABLE 2—THREAD-GAGE DIMENSIONS

Size		Diameters									General Dimensions							
		Go			Not Go, Class 2			Not Go, Class 3			Handle Size	Go		Both			Not Go	
		Pitch	Minor	Major	Pitch	Minor	Major	Pitch	Minor	Major		A	B	C	D	E	F	G
¼—20	Minimum	0.2175		0.2500	0.2211		0.2403	0.2201		0.2403	1	1½	½	¾	¼	0.239	1 5/16	5/16
	Maximum	0.2177	0.1850	0.2505	0.2213	0.1886	0.2408	0.2203	0.1876	0.2408						0.240		
¼—28	Minimum	0.2268		0.2500	0.2299		0.2431	0.2290		0.2431								
	Maximum	0.2270	0.2036	0.2505	0.2301	0.2067	0.2436	0.2292	0.2058	0.2436								
5/16—18	Minimum	0.2764		0.3125	0.2805		0.3017	0.2794		0.3017								
	Maximum	0.2766	0.2403	0.3130	0.2807	0.2444	0.3022	0.2796	0.2433	0.3022								
5/16—24	Minimum	0.2854		0.3125	0.2887		0.3044	0.2878		0.3044								
	Maximum	0.2856	0.2583	0.3130	0.2889	0.2616	0.3049	0.2880	0.2607	0.3049								
3/8—16	Minimum	0.3344		0.3750	0.3389		0.3629	0.3376		0.3629	2	1¾	¾	¾	¼	0.309	1⅜	3/8
	Maximum	0.3346	0.2938	0.3756	0.3391	0.2983	0.3635	0.3378	0.2970	0.3635						0.310		
3/8—24	Minimum	0.3479		0.3750	0.3512		0.3669	0.3503		0.3669								
	Maximum	0.3481	0.3208	0.3755	0.3514	0.3241	0.3674	0.3505	0.3232	0.3674								
7/16—14	Minimum	0.3911		0.4375	0.3960		0.4236	0.3947		0.4236								
	Maximum	0.3913	0.3447	0.4381	0.3962	0.3496	0.4242	0.3949	0.3483	0.4242								
7/16—20	Minimum	0.4050		0.4375	0.4086		0.4278	0.4076		0.4278								
	Maximum	0.4052	0.3725	0.4380	0.4088	0.3761	0.4283	0.4078	0.3751	0.4283								
½—13	Minimum	0.4500		0.5000	0.4552		0.4851	0.4537		0.4851								
	Maximum	0.4502	0.4000	0.5006	0.4554	0.4052	0.4857	0.4539	0.4037	0.4857								
½—20	Minimum	0.4675		0.5000	0.4711		0.4903	0.4701		0.4903								
	Maximum	0.4677	0.4350	0.5005	0.4713	0.4386	0.4908	0.4703	0.4376	0.4908								
9/16—12	Minimum	0.5084		0.5625	0.5140		0.5463	0.5124		0.5463	3	1⅞	⅞	¾	¼	0.408	1½	½
	Maximum	0.5086	0.4542	0.5631	0.5142	0.4598	0.5469	0.5126	0.4582	0.5469						0.410		
9/16—18	Minimum	0.5264		0.5625	0.5305		0.5517	0.5294		0.5517								
	Maximum	0.5266	0.4903	0.5630	0.5307	0.4944	0.5522	0.5296	0.4933	0.5522								
5/8—11	Minimum	0.5660		0.6250	0.5719		0.6073	0.5702		0.6073								
	Maximum	0.5663	0.5069	0.6256	0.5722	0.5128	0.6079	0.5705	0.5111	0.6079								
5/8—18	Minimum	0.5889		0.6250	0.5930		0.6142	0.5919		0.6142								
	Maximum	0.5892	0.5528	0.6255	0.5933	0.5569	0.6147	0.5922	0.5558	0.6147								
¾—10	Minimum	0.6850		0.7500	0.6914		0.7306	0.6895		0.7306								
	Maximum	0.6853	0.6200	0.7506	0.6917	0.6264	0.7312	0.6898	0.6245	0.7312								
¾—16	Minimum	0.7094		0.7500	0.7139		0.7379	0.7126		0.7379								
	Maximum	0.7097	0.6688	0.7506	0.7142	0.6733	0.7385	0.7129	0.6720	0.7385								
⅞— 9	Minimum	0.8028		0.8750	0.8098		0.8534	0.8077		0.8534	4	2 1/16	1	⅞	5/16	0.608	1 13/16	5/8
	Maximum	0.8031	0.7306	0.8757	0.8101	0.7376	0.8541	0.8080	0.7355	0.8541						0.610		
⅞—14	Minimum	0.8286		0.8750	0.8335		0.8611	0.8322		0.8611								
	Maximum	0.8289	0.7822	0.8756	0.8338	0.7871	0.8617	0.8325	0.7858	0.8617								
⅞—18	Minimum	0.8389		0.8750	0.8430		0.8642	0.8419		0.8642								
	Maximum	0.8392	0.8028	0.8755	0.8433	0.8069	0.8647	0.8422	0.8058	0.8647								
1 — 8	Minimum	0.9188		1.0000	0.9264		0.9757	0.9242		0.9757								
	Maximum	0.9191	0.8376	1.0007	0.9267	0.8452	0.9764	0.9245	0.8430	0.9764								
1 —14	Minimum	0.9536		1.0000	0.9585		0.9861	0.9572		0.9861								
	Maximum	0.9539	0.9072	1.0006	0.9588	0.9121	0.9867	0.9575	0.9108	0.9867								
1⅛— 7	Minimum	1.0322		1.1250	1.0407		1.0972	1.0381		1.0972								
	Maximum	1.0325	0.9394	1.1257	1.0410	0.9479	1.0979	1.0384	0.9453	1.0979								
1⅛—12	Minimum	1.0709		1.1250	1.0765		1.1088	1.0749		1.1088								
	Maximum	1.0712	1.0167	1.1256	1.0768	1.0223	1.1094	1.0752	1.0207	1.1094								
1¼— 7	Minimum	1.1572		1.2500	1.1657		1.2222	1.1631		1.2222	5	2⅜	1¼	1	⅜	0.808	2⅛	¾
	Maximum	1.1575	1.0644	1.2507	1.1660	1.0729	1.2229	1.1634	1.0703	1.2229						0.810		
1¼—12	Minimum	1.1959		1.2500	1.2015		1.2338	1.1999		1.2338		2⅜	1					
	Maximum	1.1962	1.1417	1.2506	1.2018	1.1473	1.2344	1.2002	1.1457	1.2344								
1½— 6	Minimum	1.3917		1.5000	1.4018		1.4676	1.3988		1.4676		2⅞	1½					
	Maximum	1.3920	1.2834	1.5008	1.4021	1.2935	1.4684	1.3991	1.2905	1.4684								
1½—12	Minimum	1.4459		1.5000	1.4515		1.4838	1.4499		1.4838		2⅜	1					
	Maximum	1.4462	1.3917	1.5006	1.4518	1.3973	1.4844	1.4502	1.3957	1.4844								

GENERAL SPECIFICATIONS FOR THREAD GAGE

PITCH DIAMETERS

Minimum, all sizes; Go—Basic; Not Go—Basic plus American Standard (N.S.T.C.) Thread Tolerance.

Maximum, ¼ to 9/16 diameter; Go—Minimum +0.0002; Not Go—Minimum +0.0002.

⅝ to 1½ Diameter; Go—Minimum +0.0003; Not Go—Minimum +0.0003.

MAJOR DIAMETERS

Minimum all sizes; Go—Basic; Not Go—Basic—15 per cent double thread depth.

Maximum 6 Threads; Go—Basic +0.0008; Not Go—Minimum +0.0008.

7-9 Threads; Go—Basic +0.0007; Not Go—Minimum +0.0007.

10-16 Threads; Go—Basic +0.0006; Not Go—Minimum +0.0006.

18-28 Threads; Go—Basic +0.0005; Not Go—Minimum +0.0005.

MINOR DIAMETERS

American Standard Form or Sharper.

CENTERS

Female.

DUST GROOVE

Go—Manufacturers' practice.

MARKING

Go—¼-Basic pitch diameter on shank end; Not Go—Minimum pitch diameter on shank end.

Go—5/16-1½ Inclusive—Size, thread and basic pitch diameter on thread end; Not Go—Size, thread and minimum pitch diameter on thread end.

THREAD ANGLE

28-20 Threads,—Tolerance in half angle ± 15 min.

18-9 Threads,—Tolerance in half angles ± 10 min.

8-6 Threads,—Tolerance in half angle ± 5 min.

LEAD ERROR

±0.0002 between any two threads, non-accumulative, not farther apart than one diameter.

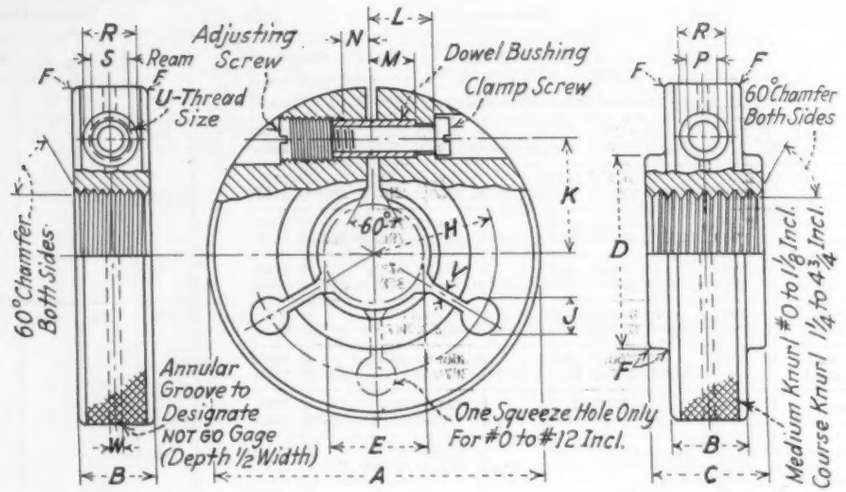


TABLE 1—RING THREAD-GAGES

Nominal Thread Size, Incl.	General Dimensions																	
	A	*B*	*C*	*D*	*E*	*F*	*H*	*J*	*K*	*L*	*M*	*N*	Drill *P*	Drill *R*	Ream S	*U* Size	*U* P.D.	*V*	*W*
0-6	1	13/64	....	....	....	1/32	5/16	5/32	5/16	7/32	5/32	1/16	41 (0.0960)	11/64 (0.1719)	0.1370 0.1373	8-36	0.1460 0.1478	0.010 Approx.	1/32
8-12	1	1/4	....	....	....	1/32	5/16	5/32	5/16	7/32	5/32	1/16	41 (0.0960)	11/64 (0.1719)	0.1370 0.1373	8-36	0.1460 0.1478	1/64	1/32
1/4-5/16	1 3/8	11/32	....	....	5/32	1/32	7/16	3/16	3/8	11/32	1/4	1/8	31 (0.1200)	7/32 (0.2187)	0.1810 0.1813	12-28	0.1928 0.1950	1/32	1/16
3/8-1/2	1 3/4	7/16	....	....	3/16	1/32	19/32	1/4	15/32	1/2	3/8	3/16	25 (0.1495)	17/64 (0.2656)	0.2150 0.2153	1/4-28	0.2268 0.2290	1/32	3/32
9/16-3/4	2 3/16	9/16	3/4	1 1/16	11/32	1/16	3/4	5/16	11/16	17/32	13/32	7/32	7 (0.2010)	21/64 (0.3281)	0.2720 0.2723	5/16-24	0.2854 0.2878	1/16	3/32
7/8-1 1/8	2 5/8	11/16	15/16	1 1/2	9/16	1/16	31/32	5/16	7/8	17/32	13/32	9/32	1 (0.2280)	25/64 (0.3906)	0.3340 0.3344	3/8-24	0.3479 0.3503	1/16	3/32
1 1/4-1 1/2	3 1/4	3/4	1 1/8	1 7/8	27/32	3/32	1 3/16	3/8	1 1/8	5/8	7/16	5/16	17/64 (0.2656)	29/64 (0.4531)	0.3890 0.3894	7/16-20	0.4050 0.4076	1/16	3/32
1 5/8-2	3 3/4	13/16	1 1/4	2 3/8	1 3/16	3/32	1 7/16	3/8	1 3/8	5/8	7/16	5/16	17/64 (0.2656)	29/64 (0.4531)	0.3890 0.3894	7/16-20	0.4050 0.4076	1/16	1/8
2 1/8-2 1/2	4 1/2	7/8	1 5/16	2 7/8	1 19/32	3/32	1 3/4	7/16	1 11/16	13/16	9/16	7/16	21/64 (0.3281)	33/64 (0.5156	0.4510 0.4515	1/2-20	0.4675 0.4701	3/32	1/8
2 5/8-3	5	7/8	1 3/8	3 3/8	2	3/32	2	7/16	1 15/16	13/16	9/16	7/16	21/64 (0.3281)	33/64 (0.5156)	0.4510 0.4515	1/2-20	0.4675 0.4701	3/32	1/8
3 1/8-3 1/2	5 1/2	15/16	1 7/16	3 7/8	2 7/16	3/32	2 7/32	7/16	2 3/16	13/16	9/16	7/16	21/64 (0.3281)	33/64 (0.5156)	0.4510 0.4515	1/2-20	0.4675 0.4701	3/32	1/8
3 5/8-4	6 3/8	15/16	1 1/2	4 5/8	2 15/16	3/32	2 5/8	1/2	2 9/16	1	3/4	5/8	13/32 (0.4062)	41/64 (0.6406)	0.5710 0.5715	5/8-18	0.5889 0.5919	3/32	1/8
4 1/8-4 3/4	7 1/4	1	1 1/2	5 3/8	3 3/8	3/32	3 1/32	1/2	3	1	3/4	5/8	13/32 (0.4062)	41/64 (0.6406)	0.5710 0.5715	5/8-18	0.5889 0.5919	3/32	1/8

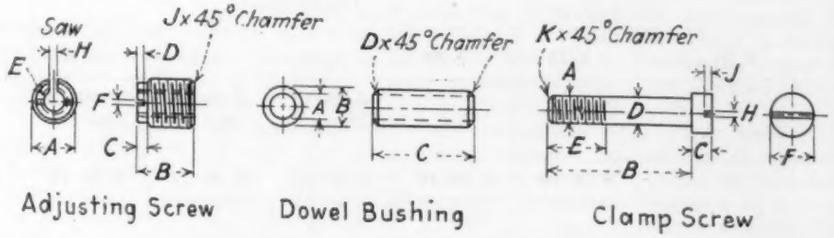


TABLE 2—RING THREAD-GAGES

Adjusting Screw											Dowel Bushing				Clamp Screw									
A		B	C	D	E			F	H	J	Drill A	B	C	D	A		B	C	D	E	F	H	J	K
Size	P.D.				Size	P.D.	Drill								Size	P.D.								
8-36	0.1442 0.1460	3/16	1/16	3/64	2-64	0.0759 0.0773	50 (0.0700)	1/32	1/64	0.020	43(0.0890)	0.1368 0.1370	1/4	0.010	2-64	0.0745 0.0759	29/64	5/64	0.0840 0.0860	3/16	5/32	1/32	3/64	0.010
12-28	0.1906 0.1928	9/32	1/16	3/64	4-48	0.0985 0.1001	42 (0.0930)	1/32	1/64	0.020	32(0.1160)	0.1808 0.1810	7/16	0.020	4-48	0.0969 0.0985	23/32	3/32	0.1100 0.1120	5/16	3/16	1/32	3/64	0.020
1/4-28	0.2246 0.2268	5/8	5/64	1/16	6-40	0.1218 0.1235	32 (0.1160)	3/64	1/32	0.020	27(0.1440)	0.2148 0.2150	5/8	0.020	6-40	0.1201 0.1218	1	1/8	0.1360 0.1380	7/16	7/32	3/64	1/16	0.020
5/16-24	0.2830 0.2854	3/8	5/64	1/16	10-32	0.1697 0.1716	20 (0.1610)	3/64	1/32	1/32	10(0.1930)	0.2718 0.2720	11/16	1/32	10-32	0.1678 0.1697	1 1/16	1/8	0.1880 0.1900	7/16	9/32	3/64	1/16	1/32
3/8-24	0.3455 0.3479	7/16	5/64	1/16	12-28	0.1928 0.1950	14 (0.1820)	1/16	3/64	1/32	2 (0.2210)	0.3337 0.3340	3/4	1/32	12-28	0.1906 0.1928	1 3/16	5/32	0.2140 0.2160	1/2	11/32	1/16	1/16	1/32
7/16-20	0.4024 0.4050	1/2	3/32	5/64	1/4-28	0.2268 0.2290	3 (0.2130)	1/16	3/64	1/32	F (0.2570)	0.3887 0.3890	13/16	1/32	1/4-28	0.2246 0.2268	1 23/64	3/16	0.2480 0.2500	9/16	13/32	1/16	5/64	1/32
1/2-20	0.4649 0.4675	9/16	1/8	3/32	5/16-24	0.2854 0.2878	I (0.2720)	5/64	1/16	3/64	P (0.3230)	0.4507 0.4510	1 1/16	3/64	5/16-24	0.2830 0.2854	1 23/32	1/4	0.3105 0.3125	5/8	15/32	5/64	3/32	3/64
5/8-18	0.5859 0.5889	5/8	1/8	3/32	3/8-24	0.3479 0.3503	Q (0.3320)	5/64	1/16	3/64	25/64(0.390)	0.5707 0.5710	1 1/2	3/64	3/8-24	0.3455 0.3479	2 3/16	5/16	0.3730 0.3750	3/4	19/32	5/64	3/32	3/64

Tire and Rim Division

PERSONNEL

H. M. Crane, *Chairman*	New York City
T. J. Litle, Jr., *Vice-Chairman*	Marmon Motor Car Co.
C. S. Ash	Wire Wheel Corporation of America
R. S. Begg	Jordan Motor Car Co.
C. Breer	Chrysler Corporation
C. C. Carlton	Motor Wheel Corporation
B. Darrow	Goodyear Tire & Rubber Co.
D. H. Fenton	Fisk Rubber Co.
W. T. Fishleigh	Ford Motor Co.
T. G. Graham	B. F. Goodrich Co.
W. R. Griswold	Packard Motor Car Co.
J. E. Hale	Firestone Tire & Rubber Co.
K. L. Herrmann	Studebaker Corporation of America
O. E. Hunt	Chevrolet Motor Co.
A. H. Knight	Dodge Brothers
H. W. Kranz	Cleveland Welding Co.
B. J. Lemon	United States Rubber Co.
E. S. Marks	H. H. Franklin Mfg. Co.
W. B. Minch	Jaxon Steel Products Division, General Motors Corporation
Maurice Olley	Rolls-Royce of America, Inc.
G. E. Parker	Cadillac Motor Car Co.
L. Thoms	Graham-Paige Motor Corporation
A. J. Scaife	White Motor Co.
J. G. Swain	Firestone Steel Products Co.
C. P. Thomas	Reo Motor Car Co.
F. E. Watts	Hupp Motor Car Corporation

BALLOON-TIRE SIZES

The accompanying table of tire and rim sizes and the proposed method of marking are the result of a series of meetings held separately and jointly by the S.A.E. Special Advisory Committee, the Tire and Rim Division, the Tire and Rim Association, and the Rubber Association of America, with representatives of the National Automobile Chamber of Commerce. The 18 tire-sizes proposed as standard have been approved by the Board of Directors of the National Automobile Chamber of Commerce and recommended for use by the members.

The proposed method of marking was put into effect by some of the tire companies on May 15. It is anticipated that marking of tires with the former name-size in small characters, as indicated below the table, will be eliminated gradually as service requirements allow of this.

The specifications, as recommended to the Standards Committee for approval as an S.A.E. Standard, are given on the following page.

BALLOON TIRES AND RIMS

(S.A.E. Standard)

Rim Diameter	Tire Sections							
	4.50	4.75	5.00	5.25	5.50	6.00	6.50	7.00
18				**5.25–18** *(28x5.25)*	**5.50–18** *(28x5.50)*	**6.00–18** *(30x6.00)*	**6.50–18** *(30x6.50)* *(30x6.20)*	**7.00–18** *(32x7.00)* *(30x6.75)*
19		**4.75–19** *(28x4.75)*	**5.00–19** *(29x5.00)* *(28x4.95)*	**5.25–19** *(29x5.25)*	**5.50–19** *(29x5.50)*	**6.00–19** *(31x6.00)*	**6.50–19** *(31x6.50)* *(31x6.20)*	
20		**4.75–20** *(29x4.75)*	**5.00–20** *(30x5.00)* *(29x4.95)*		**5.50–20** *(30x5.50)*	**6.00–20** *(32x6.00)* *(30x5.77)*	**6.50–20** *(32x6.50)* *(32x6.20)*	**7.00–20** *(34x7.00)* *(32x6.75)*
21	4.50–21							
Rim-Section Width[1], In.	2.75 Flat Base or Drop	4	4	4	4	4½	4½	5
Maximum Tire Width on Rim, In.	4.75	4.85	5.15	5.35	5.60	5.95	6.40	6.90

[1] Rim widths given are nominal except the 2.75-in. size, which dimension is the actual width between flanges.
Method of Marking.—Tires shall be marked with the tire cross-section followed by the rim diameter on which the tire shall be used; under which designation shall be placed, in small figures, the former name-size or sizes of the tires replaced.

Walter Wardrop

THE automotive industry, particularly the motor-truck branch, has lost a valued advocate, and the ranks of the automotive trade-paper men have lost a pioneer member, in the deplored passing of Walter Wardrop, president and general manager of the Power Wagon Publishing Co., on April 29, following a brief attack of pneumonia.

Mr. Wardrop was one of the real "old-timers" in the automotive publishing field and brought to it a superior education and a keen insight into the economics of motor transportation. Founder of *Cycling Life*, the first American trade-journal devoted solely to the mechanical and commercial aspects of the bicycle industry, Mr. Wardrop merged this with *The Referee* and *Bearings*, two contemporaneous Chicago bicycle journals, in the late nineties, and became one of the major stockholders in *Cycle Age*. This journal a few years later was transformed into an automobile periodical and renamed *Motor Age*. For a few years he was associated in Cleveland with A. L. Garford and with Hayden Eames, in the supplying of constructional parts for electrical vehicles. There he founded *The Automobile Builder*, the predecessor of *Power Wagon*, which he established in 1906 and of which he was the publisher continuously during the last quarter century, directing the policy of this journal primarily to the economic phases of motor-trucking and motor-coach operation.

Mr. Wardrop was born in Dublin, Ireland, in 1864, and studied medicine in Dublin and in a post-graduate course in Germany. He was a scholarly writer and speaker and, after coming to America and entering trade journalism in Chicago, he performed an important part in influencing the development of the bicycle and motor-vehicle industries. Some years ago he suffered a nervous breakdown that forced him thereafter to conserve his strength and to withdraw from active participation in gatherings of the industry to which he was so devoted.

Mr. Wardrop had been a member of the Society since his election to Member grade in 1910. As a past master at fly fishing, he was a member of the Izaak Walton League of America, the Mission Hill Country Club of Chicago, and of other sports and boating organizations. Funeral services were held at his residence in Evanston, Ill., and interment was at Olivet Cemetery, Aurora, Ill. He is survived by his widow, Mrs. Harriet Sullivan Wardrop.

To those who knew him, Mr. Wardrop possessed a magnetic and lovable personality and great simplicity, with which was combined keen understanding of the problems involved in the production, distribution, operation and maintenance of commercial motor-vehicles.

Milton Beck

AS a member of the Society since 1917 and a pioneer in gas and gasoline-engine research and designing, the passing, on April 23, of Milton Beck, chief engineer of Stanley Steamer, Inc., of Chicago, at his home in Valparaiso, Ind., is greatly deplored.

Mr. Beck was born at Macomb, Ill., in 1876 and acquired his technical education at the South Dakota State College and at Purdue University, being graduated from the former institution with the degree of bachelor of science. As chief draftsman for the Olds Motor Works during the period 1900 to 1902, he was engaged in designing the first Oldsmobile.

During the succeeding 7 years, as chief engineer for the Alamo Mfg. Co., of Hillsdale, Mich., he was occupied in designing internal-combustion engines and tractors. His next work was special designing, research and testing on automobile parts as research engineer for the Ferro Machine & Foundry Co., of Cleveland. In the same capacity with R. E. Olds during 1913 and 1914, Mr. Beck did special research work on tractors. For the Van Blerck Motor Co., of Monroe, Mich., he did special research work and gave lectures on internal-combustion engines in the company's shop and at the Charleston, S. C., Navy Yard.

During the war period Mr. Beck did his bit by working on research, inspection and checking design on Duesenberg, Liberty and Bugatti aeronautic engines for the Duesenberg Motor Corporation at Elizabeth, N. J., and later at the company's Chicago plant. After the termination of the war, from 1919 to 1923, in the capacity of vice-president in charge of design for Page Beck White of Chicago, he had supervision of commercial engineering on steam and internal-combustion engines

for tractors and motorcoaches. In 1923 he became chief engineer of the Stanley Motor Carriage Co., of Newton, Mass., and subsequently returned to Chicago in the same capacity with this company.

Besides holding the grade of Member in the Society of Automotive Engineers, Mr. Beck was a member of the American Society of Mechanical Engineers.

The loss of a veteran engineer of such attainments and such long and broad experience in the automotive field cannot be regarded as other than a heavy one to the industry.

Paul V. Clodio

WITH sincere regret the recent death of Paul V. Clodio, sales manager of the company, was announced on May 14 by the Bragg-Kliesrath Corporation, Long Island City, N. Y.

Mr. Clodio was elected an Associate Member of the Society in November, 1917, at which time he was president and technical manager of the Houdaille Shock Absorber Co.

Born at Paris, France, in 1882, Mr. Clodio came to the United States at an early age and acquired his general academic education at the St. Ann's Academy, in New York City, and later took out citizenship papers. He spent the years 1898 to 1900 as draftsman and designer on general woodwork with Bradley & Co., of New York City, and the next 13 years successively with the Cudell Motor Co., Pope Mfg. Co., Mercedes Import Co., Benz Automobile Import Co., and Benz Automobile Sales Corporation, all in New York City. His position with the Cudell, Mercedes and Benz Import companies was that of manager. For the Pope company he was assistant manager of the New York City branch in charge of sales, and for the Benz Automobile Sales Corporation he was president. During 1916 and 1917 Mr. Clodio was vice-president and manager of Clodio & Engs, Inc., of New York City, metropolitan distributors of Kissel Kars. In 1917 he became president of the Houdaille Company. From 1918 to 1924 he was metropolitan agent for the Kissel and the Cole cars, and in the latter year joined the Bragg-Kliesrath Corporation as sales manager. His home was in Flushing, Long Island.

Frank F. Schiefe

FOLLOWING an illness which made it necessary for him to relinquish his position as project engineer with the C. Spiro Mfg. Co. because of the rigorous winter climate in Dobbs Ferry, N. Y., Frank F. Schiefer finally passed away this spring.

Mr. Schiefer was elected to Associate Member grade in the Society in April, 1926, and subsequently became a member of the Metropolitan Section, as he was a resident of New York City.

Born in Vienna, Austria, in 1891, he was graduated from the Technical University with the degree of mechanical engineer in 1914. For the following 9 years he was successively connected as chief engineer with several airplane and motorboat companies in Vienna and in Sweden, engaged in stress calculation, details and quantity production of airplanes and in motorboat designing.

Coming to the United States in 1923, Mr. Schiefer joined the engineering staff of the International Motor Co. as design engineer, working on stress calculations and details of the Mack motorcoach. The following year he went with the Curtiss Aeroplane & Motor Co., at Garden City, N. Y., for which he worked on details and stress calculations on all-metal airplanes. In 1925, as chief engineer for Charles Hvass & Co., of New York City, he carried on similar work on the company's 50-ton trailers. His last position was, as stated, chief engineer of the C. Spiro Mfg. Co., of Dobbs Ferry.

Mr. Schiefer was a regular contributor on airplane subjects to *Flugsport*, the German aviation magazine published in Frankfort on the Main.

Vaughan John Weatherley

A JUNIOR MEMBER of the Society of great promise in the aeronautic field, Vaughan John Weatherley, aeronautic engineer with the Wright Aeronautical Corporation, of Paterson, N. J., met an untimely and deplored end in an airplane crash on the golf-club course at Teterboro, N. J., on May 9. He was accompanying Lieut. Royal V. Thomas on a test flight in a Bellanca airplane in which Lieutenant Thomas, who was also killed instantly in the crash, planned to make a transatlantic flight to Rome the following week.

The precise cause of the accident is not known, but from accounts of eyewitnesses, Giuseppe M. Bellanca, designer and builder of the airplane, who was watching tests of a new airplane at Hadley Field, New Brunswick, N. J., at the time and hurried to Teterboro, expressed belief that, in an attempt to glide to a landing on the golf course when the engine began to sputter, the craft went into a sideslip and struck the ground. It was completely wrecked.

Mr. Weatherley was only 26 years of age, having been born at New Rochelle, N. Y., in April, 1901, but was married and lived in Ridgewood, N. J. He attended the Choate Preparatory School from 1917 to 1920 and the Massachusetts Institute of Technology from 1920 to 1925, where he took the general engineering course, giving special study to automotive and aeronautic engineering. While studying at the Institute, he was an Enrolled Student of the Society and was a member of the M. I. T. Aeronautical Engineering Society, for which he served as board treasurer, conducted research on light airplanes, and assisted with the aeronautic meetings.

From 1920 to 1924 Mr. Weatherley was in the Reserve Officers Training Corps of the Army Air Service and qualified as a second lieutenant observer, and in the latter year became an ensign and pilot in the Naval Reserve Force. His first commercial connection was effected in 1925 with the Wright Aeronautical Corporation, for which he was engaged in observation work in various departments of the engine manufacturing plant and in experimental engineering.

Charles M. Schwab

RUN over by an automobile and fatally injured, Charles M. Schwab, secretary and engineer of the Metallic Window Frame Co., of New York City, passed away at his home in Brooklyn, N. Y., on May 8, mourned by his widow and many friends.

Mr. Schwab was elected to the grade of Associate Member in the Society in 1917, and the following year was transferred to the grade of Member. He was also a member of the Metropolitan Section.

He was a native New Yorker, born in the city in 1886, and studied mechanical engineering at Cooper Union Institute during the years 1904 to 1906. His connection with the automotive industry began the following year and continued without interruption for the remaining 11 years. From 1907 to 1911 he worked with the Smith & Mabley Mfg. Co. as designer on the American Simplex automobile, and with the American Locomotive Co., at Providence, R. I., as designer and on production work, planning, scheduling and writing operation instructions on the Alco car. During the two succeeding years Mr. Schwab was engaged in design work for the United States Motor Co. At the time of his election to membership he had been connected with the General Vehicle Co., of Long Island City, for 4 years, since 1913, and held the position of production engineer in the company's airplane engine division during the war.

Prior to entering the field of automobile designing, Mr. Schwab, while attending Cooper Union at night, served as machinist and tool-maker for various firms, and in the testing laboratory of the Cooper Hewitt Electric Co. Then for more than a year he was designer of oil and gas engines for August Meitz, of New York City.

News of Section Meetings

(*Continued from p. 696*)

the troubles with motor-trucks in service.

The body must be designed according to the load it has to carry. The body builder must construct, not only stake and panel bodies, but specialized jobs such as refrigerator bodies and even one that will carry a load of 10 tons suspended from the roof. Mr. Wood gave an example of weight reduction in a body built for the Morris Draying Co., the dimensions required being 13 ft. long and 7 ft. wide. The weight to be carried was 7 tons. Bodies that had been built weighed about 1500 lb., but, to carry a certain tonnage on the runs, it was desired to reduce this weight to 1000 lb., and this was more than realized.

Among the expedients adopted were the use of 1⅛-in. pine instead of ⅞-in. hardwood for the floor, making a saving of about 56 lb.; 2 x 3-in. sills in place of 2½ x 5-in., saving 45 lb.; and a reduction in the section of the cross-members at the ends and between the points of support, saving 116 lb. The cross-members were narrower and therefore were trussed like the floor timbers of a house, adding to the weight about 17 lb. Reductions were made in the section of the sub-sill resting on the chassis frame and in the material of the head-board for which oak was used in the top board only. Where the 1⅜-in. cross-members rested on the 2-in. sub-sill, bearing plates were provided to give a greater supporting surface. To save drilling a hole through the two members at the intersection, the plate was bolted to each side of the cross-member, with a yoke on top.

Figures given by Mr. Wood on the strength of wooden beams showed that the cross-members generally used for truck bodies are much heavier than they need to be. Very small steel angles are said not to support quite so great a load as a section of wood having the same weight, but the condition is reversed with large and medium-size angles.

Mr. Wood closed his talk with a plea for proper cooperation of the chassis-selling organizations with the body builders and for the gathering of more information on the actual weight of bodies in service.

Chairman Penfield remarked, on the question of weight, that he once weighed a truck before and after it was painted, finding that the weight of paint added was 75 lb. He suggested lighter weight as a selling point for paint salesmen.

Public Utilities Use Standard Bodies

Body Designs for Public Utility Work was the subject of a paper read by V. W. Dennis, supervisor of motor vehicles, of the Pacific Telephone & Telegraph Co., San Francisco, who was the last speaker. After a few words on the development of the driver's cab and the body in general, Mr. Dennis said that his own and other public-utility companies now are using two bodies; one known as Type B and the other as Type C. The former is provided with boxes above the floor level, that open at the outside, to carry a supply of small material and tools for use on the job. This saves much confusion and loss of time. In Type C the boxes are omitted and a collapsible pole-derrick is carried on one side and block and tackle on the other side. The truck is provided with a winch, and the body must be extra strong for this service. A bar containing a roller sheave can be mounted across the top of the body, and an adjustable leg, having a flat shoe to rest upon the ground, can be installed directly under the point at which the derrick is located.

Provision for Crew Comfort

Careful provision is made for the comfort of the driver and crew. The cabs are fully inclosed and provided with windows and ventilators. Consideration is given to the design of the seat cushion, windshield and other items. In the top of the cabs are built sheet-metal racks for first-aid kits and such articles as blueprints, specification sheets and books.

S. B. Shaw said that the Pacific Gas & Electric Co., with which he is connected, uses similar bodies for trucks of 2 and 2½-ton capacity. They have sought lighter weight by the use of metal, some of their latest bodies being made entirely of steel except for the floor. Mr. Shaw made a plea for the use of standard dimensions on truck chassis for mounting the bodies. He remarked that standard dimensions have been established by the Society but that they are not followed sufficiently by truck manufacturers.

At the close of the meeting mention was made by E. C. Wood and Chairman W. S. Penfield of a proposal to establish an aeronautic division in the Section. The matter had been discussed with the Governing Committee of the Section by Second Vice-President H. C. Dickinson. A special committee that was appointed has found that there is considerable interest in the proposal.

Sunshine Drives Car

OUR modern wagons are hitched to the sun; the engine is the harness and gasoline represents concentrated sunshine. Such was the theme around which T. A. Boyd, of the General Motors Corporation Research Laboratories, wove a vivid presentation, at a meeting of the Student Branch of the Society in the University of Detroit on May 14, of our modern ability to utilize the radiant energy of our source of life to give us the power used in transportation.

Our automobiles are consuming annually as great a flood of gasoline as the volume of water that burst the St. Francis dam above Los Angeles last March and wrought such havoc, and our year's engine fuel contains solar energy equivalent to 15 times the waterpower that could be generated by all the water flowing over Niagara Falls in a whole year, according to the speaker. Although people sometimes talk of how wonderful it would be if we could run our racing cars on some high explosive such as nitroglycerine or TNT, the fact is that gasoline contains a great deal more available energy than any of these, being at the same time much cheaper and safer to use.

At 20 m.p.h. only 8 per cent of the chemical energy of the motor fuel is utilized in driving the vehicle; 80 per cent is lost in heat that passes out in the exhaust or is dissipated by the cooling water.

After explaining briefly and clearly the way in which the internal-combustion engine functions by the combustion of the air-fuel mixture, and how the reciprocating movement of the pistons is transformed into rotary motion and drives the car, Mr. Boyd discussed high compression in the engine as a means of salvaging a somewhat larger portion of the molecular motion and using it to drive the vehicle. Continuing, he discussed detonation, mean effective pressure, volumetric efficiency and other factors influencing engine performance.

Ways to Decrease Knock Tendency

Four ways of improving fuels to decrease the tendency to knock were listed as (*a*) adding small quantities of

a knock preventive such as tetraethyl lead or iron carbonyl, (*b*) adding to the basic fuel a percentage of another fuel, such as benzol or alcohol, that is free from the tendency to knock, (*c*) cracking heavy petroleum oils into gasoline by means of heat, and (*d*) selecting crude oils which by their nature yield gasoline of good antiknock properties.

The truth is, he said in conclusion, that while excellent theories of the cause of detonation have been advanced, they fail to explain the phenomena; it is a little like the comment on the word "doughboys," applied to our soldiers during the World War, by a man who said, "Doughboys is an excellent name except that they were not boys and were not the ones who got the dough."

Following Mr. Boyd's address, Mr. Stewart, of the Lufkin Tool Co., gave a short talk on new developments in micrometers, calipers, scrapers and other machinists' tools, and exhibited a sample of a new students' tool-kit which he designed in cooperation with the professors of the General Motors Institute of Technology at Flint, Mich.

Birth of the Student Branch

Following a long period of enthusiastic work by John Caton, professor of automotive engineering and coordinator of the University of Detroit, devoted to arousing interest in the matter, the organization of this new Student Branch in the Society was voted for at the Feb. 13 meeting of the Detroit Section. Shortly thereafter, John H. Hunt, past-president of the Society, and Walter T. Fishleigh, chairman of the Detroit Section, formally organized the Branch at the university and welcomed the member students into the Society. At the next Detroit meeting the University of Detroit Student Branch had 100 reservations for the dinner and the student group was introduced to the Detroit Section members by Mr. Fishleigh and given a rousing welcome. Some time later the Student Branch held an organization meeting at which a charter was drawn up and adopted and officers elected as follows:

John Caton, honorary chairman; William Perfield, chairman; George McCormick, vice-chairman; Joseph Muffat, corresponding secretary; Vincent Hogan, recording secretary; and Merrill Grix, treasurer.

This is the fourth Student Branch in the Society, the others being at Ohio State University, Massachusetts Institute of Technology, and the General Motors Institute of Technology, Flint, Mich. The latest addition to the family is a bouncing youngster with more than 250 members. The aim of the happy parents is, by careful nurturing, to so increase the size of the infant within the next year that it will no longer be regarded as the baby of the family.

Season Closes at Detroit

C. F. Kettering Helps the Section to Get an Edge on Super-Activity Next Fall

A REPORT from the Detroit Section says: "We ended the season with a bang on May 7, as we threatened to do. There were 720 at the dinner in the grand ballroom of the Book-Cadillac Hotel, about 850 attended the technical session, every available bit of space

C. F. Kettering

was occupied, and Kettering told us what was what."

Beulah says that "the dance started about 10:30 p.m. and continued until 12:15 a.m., at which time there were still about 200 couples present. An 11-piece band supplied snappy music and a dancing team provided entertainment during the intermissions. This evening certainly was a fitting climax for a successful season." And, under date of May 10, nearly 3 days later, she says further: "I haven't come to earth yet!" Upon this evidence it seems safe to conclude that the Section attained a high ceiling.

Slavery as an Asset

Practically every one of the great civilizations developed to its height at the time it possessed the greatest number of slaves, said C. F. Kettering while addressing the technical session. The maximum number of slaves per citizen in the Roman Empire was approximately eight, and following that period the Empire became decadent. Human slavery meant power, but it was power of the wrong sort and when slaves rebelled or died the power was lost. But inanimate power under control is a slave that has become an indispensable asset, and the United States has a greater command over such slavery than has any other country in the world.

Some of the representative present-day slaves he cited are electricity, the telephone, telegraph, radio, water power, steam, and automotive engines. Of these, perhaps none is greater than the inanimate individual transportation facility provided by the automobile. It has increased beyond measure the range of contact of the average individual. In addition, communication has developed as the result of patient work of the research and the designing engineers. They have controlled the forces which have existed in the world since its formation, and have made slaves of them to so great an extent that at present we have approximately 14 developed horsepower for each individual in this Country, a slave potentiality such as no other nation in the world has ever had.

Mr. Kettering voiced his satisfaction in the fact that the engineer has finally taken his proper position in the industrial world. For many years industry was developed around products which had been created by inventors, of whom the business man's idea was said to be that they should be kept secluded. It has been only within the last 10 years that the men of this type, now called engineers, have had the recognition they deserve.

Facilitating Human Effort

Quoting some statistics regarding the automotive industry, the speaker said that in the United States there is one automobile for every 5 persons; in Germany, one for every 141; in France, one for every 46; in England, one for every 45; in Canada and New Zealand, one for every 11; in Russia, one for every 1600; and in China, one for every 26,000. This is an interesting commentary on the degrees of their respective national development.

Only 30 per cent of the world's population has contributed anything to the development of machinery, Mr. Kettering said, and therefore 70 per cent of the people in the world have done nothing whatever toward facilitating human effort. The net result is that the United States stands today so pre-eminent in the development of engineering practice that this is not only a credit to the engineer but makes it also an

honor to be connected with the engineering profession. In the modern sense of the word, the engineer has tried to evaluate, to predict and to develop ideas that have facilitated normal human energies so that, today, the individual has abilities for accomplishment many times greater than otherwise could be true. Because of the automobile he has been given a freedom such as he never dreamed he could have. Along with the automobile have come all the things that are built around the internal-combustion engine; that is, trucks, tractors, motorboats, airplanes and airships. It has been most significant that automotive engineers have been able to build a powerplant that goes with each vehicle, and thereby to create the means for individual transportation.

The speaker mentioned having known of companies that were in bad shape financially but which have accelerated business by creating public demand for their products and later have paid off back debts and declared dividends. The point he emphasized in this respect was that if engineering applications can accomplish such a result for a company that is in bad financial condition, how much greater an impulse the company would have had if it had adopted these measures before they became so necessary. "Instead of looking always for some park bench along the highway of progress on which to seat ourselves and rest," he said, "we recognize that we must keep looking forward for new things and must keep changing. We must realize that each year requires change because of the fact that another year has gone by."

Future Possibilities

In Mr. Kettering's opinion, predictions for the future of the automobile business are difficult because we are dealing with such important and intricate subjects that we cannot comprehend them. No reason exists why we should not have express highways for automobiles and maintain car speeds of 60 m.p.h. or more. Referring to the phenomenal progress made lately in the science of chemistry, he used this as an illustration to indicate that many of the things we have formerly regarded as being impossible were impossible because we could not analyze them.

Mr. Kettering said also that there is no limit to development and improvement of any of the things that we now know, the reason being that we know practically nothing about the great forces behind nature. We need greater imagination to create images of desirable things, but we have been using so far only a small amount of the power available. The opportunities and possibilities of the future are as great as they have been in the past, but they constitute different problems. We fail to recognize that the commonplace thing of today is the thing that leads to the extraordinary product of tomorrow.

Regarding education, Mr. Kettering deplored what he calls encyclopedic training. He said that knowledge is being conveyed to students too largely by asking academic questions and getting academic answers. We fail to recognize that the difference between a successful man and a man who fails lies in the amount of intelligence he has. He said also that, in our modern educational system, we are doing too little toward developing students' intelligence, and he defined intelligence as the ability to use information.

We need to recognize, said Mr. Kettering, that the question of success or failure in engineering is measured finally by the bank account of the organization for which the engineer works. The figures written in red ink indicate the hisses of the community and tell the engineer that he is not wanted. The figures in black ink represent the applause, and the community thus applauds the things the engineer has done successfully. Every time the engineer does something well, he is doing something toward human progress. If the man in the field can get along with the engineer's product and it works satisfactorily for him, he buys more of it. If the engineer cannot design or build products that commonplace people can use, no matter how great an accomplishment it is, his engineering has not progressed very far. The possibilities for the engineer are far greater now than ever before, and they will continue to be greater in proportion as engineers evaluate truly the relationship between their work and the commercial phases of the automotive industry.

Engines of Racing-Car Type

Duesenberg Outlines Recent High-Speed-Engine Trend and Development

MARKED improvement in high-speed high-efficiency engines will be accomplished during the next few years, said Frederick S. Dusenberg while addressing the Milwaukee Section on May 2. They will have better balance, be longer lived, develop more power with greater efficiency, and be more satisfactory to the motoring public. He then went on to give details of the recent developments in this class of engine, after remarking that the present trend is toward a large number of small changes in design and construction rather than toward radical departures from former design and methods.

The dinner at the Milwaukee Athletic Club was attended by 101 members and guests, and 125 were present at the technical session, a preliminary feature of which was a burlesque demonstration of a most wonderful new engine of ultra-futuristic design and performance, staged by Henry L. Debbink and Arthur R. Constantine. Some idea of the humorous features of the demonstration is conveyed by the preposterous description of its construction given by "Professor" Debbink and "Herr" Constantine in the course of a dialogue, in which their explanations of why they had made radical departures from present constructive practice included sly hits that poked fun at prominent designers and engine builders. According to their claims, their efforts had resulted in a 10-cylinder single-cycle racing-car engine of 91.5-cu. in. capacity as originally intended but which had been changed to 95-cu. in. capacity to simplify the calculations so that each cylinder could be of 9.5-cu. in. capacity without having too many decimal places. Each stroke of the engine was claimed to be a power stroke, thus eliminating all the wasted strokes of the two-cycle and the four-cycle types. The equipment included, so they said, two carbureters, a small down-draft non-condensing intake manifold, a philharmonic balancer to eliminate the centrifugal forces that cause such great losses of inertia, a supercharger and a stationary flywheel. All these, and other advantageous features, soberly presented, were productive of great hilarity.

High-Speed High-Efficiency Engines

Mr. Duesenberg showed numerous lantern-slide views of his 91-cu. in. racing-car engine and its parts, commenting upon the main features of design and the troubles that had necessitated design changes. The combustion-chamber is the most important contributor to high efficiency, he said. If the shape of the combustion-chamber, the area and location of the valves, and the location of the spark-plugs are not right, all the other refinements of detail are of little value.

Stating that the intake manifold is no doubt second in importance, Mr. Duesenberg said further that this is particularly true with present fuels and becomes of even greater importance as the speed of the engine increases. The firing order, the length, size and number of bends in the mani-

fold, affect the performance to such an extent that there is no hard and fast rule to work from. Apparently the manifold that gives top-speed performance does not give best results at low speed, and the manifold for best economy does not give high-speed performance. Therefore the best that can be accomplished is a compromise, and, unless a manifold can be perfected so that double carburetion becomes possible and practicable, he sees no means of obtaining correct mixtures at all speeds.

Effect of Valve Details

Regarding valves, valve area, and operating mechanism, which the speaker mentioned as important factors in obtaining high speed, efficiency and performance, valve area does not seem to be an important factor at low speeds; but for high speeds it is the controlling factor unless a supercharger is used. In the latter case the pressure created by the supercharger can offset to some extent the deficiency in valve area. The actual valve area is not all that must be considered. The shape of the valve, its circumference and the surrounding contour of the head all play an important part.

Concerning the comparative merits of the tulip and the mushroom types of valve, Mr. Duesenberg stated that he doubts if any great difference in actual performance exists. He believes the tulip type is better adapted for intake on account of its better streamlining. For the exhaust, he advocates the mushroom type because it has less surface exposed to the heat and the heat has a better effect on keeping the valve seated.

The speaker mentioned that the valve-seat angle is of considerable importance in connection with high speed. Comparing the 30-deg. angle seat with the 45-deg. angle seat, he stated that it is possible to get considerably greater area and a better opening for the same amount of lift with the former. The reason the angle is important is that the speed of the engine is controlled mainly by the ability to move the valves fast enough and to get the best possible amount of intake area.

Opinions Differ Regarding Pistons

Commenting on pistons and piston-rings, Mr. Duesenberg said that there is a very wide range of opinion as to what constitutes correct piston-design. All agree that a piston should fit the cylinder as closely as possible so that the rings can function and be separated from the cylinder-walls only by a thin film of oil, so that they do not score. The difficulty of accomplishing this, however, lies in securing a uniform fit for the full length of skirt when either hot or cool, in keeping oil on this surface, and in keeping oil off of the piston-head. From his recent experience, he concludes that no set rule can be used to get satisfactory results. He cited one instance in which most excellent results were obtained with a very plain piston having three plain compression-rings and no oil ring.

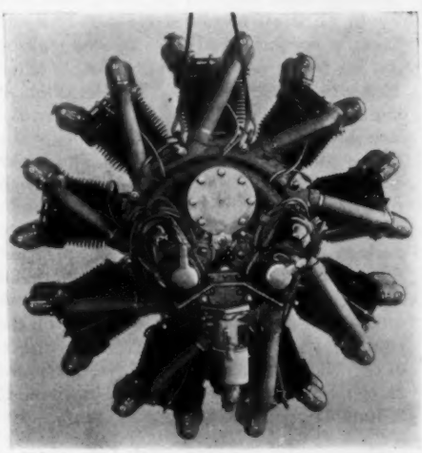
In answer to numerous questions asked after the presentation of his paper, Mr. Duesenberg made liberal use of lantern-slide views and went further into detail regarding construction features, giving also citations of experiences while testing new designs of engines and parts. He also exhibited samples of parts which had been used in service, particularly of pistons and piston-rings, and mentioned their advantages and disadvantages. The subjects of lubrication and of heat dissipation were also discussed, as well as the power required for supercharging and the methods for lubricating superchargers.

It was announced by Chairman Fred M. Young that the following Section officers had been elected for the coming year: Cyrus L. Cole, chairman; Arthur C. Wollensak, vice-chairman; R. W. Ballentine, treasurer; and Henry L. Debbink, secretary.

Radial Aero-Engine Design

Brewer Tells of Details To Consider in Designing Commercial Engines

ABOUT 150 members of the Pennsylvania Section met in Philadelphia on May 8 to hear Capt. Robert W. A. Brewer, consulting engineer, read his paper on the designing of radial air-cooled engines for commercial airplanes, which had been delivered about a month before to the Society of Engineers, Inc., in England. More than one-half of those who attended the Philadelphia meeting also attended the Section dinner, which preceded it.



Radial Engine Designed by Brewer

Rear View of Aeronautic Engine Described at Pennsylvania Section Meeting. Cylinders Are 4¼ x 5 in., Cast Iron. The Engine Weighs 455 Lb. and Develops 160 Hp. at 1800 R.P.M.

As the speaker designed a fixed radial-engine in 1921, he has been closely identified with engines of this type for a long time. Among the advantages claimed for them by Mr. Brewer are accessibility, absence of troubles with the cooling system at both extremes of temperature, and adaptability for a geared propeller because of freedom from torsional vibration. The provision of a scavenging oil-pump, together with cylinders protruding into the crankcase, is given as the key to the overcoming of early difficulties from over-oiling of radial engine-cylinders.

One of the leading objects of an airplane-engine designer is to obtain the greatest possible ratio of power to weight, combined with trustworthiness. To do this it is necessary to stress each portion of the material of the structure to the greatest permissible amount during the greatest possible proportion of the time the engine is in operation. In this respect the radial engine has a great advantage over the in-line engine, because a single section of the crankcase and a single throw of the crankshaft do duty for a multiplicity of cylinders.

Extreme Lightness Not Required

Designs of military and commercial engines differ in that, in the former, the utmost of performance is demanded regardless of cost, whereas commercial operators require economy in first cost and upkeep, even at the expense of a little additional weight. This difference in attitude affects both the structural design and the fuel requirements, since it is desirable for the commercial engine to operate on ordinary commercial gasoline.

Generally, it is desirable to design a radial engine with cylinders as large in bore as can be crowded around the crankcase without piston interference and within a reasonable over-all diameter. With the customary arrangement of a master connecting-rod, it has been

necessary to choose between a split-end master connecting-rod with a one-piece crankcase and a solid rod at the expense of providing a two-piece crankshaft and a crankcase split through the central plane of the cylinder; but the author has applied, to engines he has recently designed, a solid master-rod with a link assembly that can be mounted on the crankshaft through the end cover-plate of the crankcase.

Weight of Cast-Iron Cylinders

One of the problems in designing the connecting-rod assembly is to space the links on the master rod so that the pistons shall come to their top centers at equally spaced time-intervals. This can be done without varying the radial height of the cylinders by crowding the links on the side opposite the master rod. Cast-iron cylinders in a commercial-size engine can be made to weigh less than 18 lb. each, complete with heads, valve pockets, mounting flanges and cooling ribs.

For a commercial engine, Mr. Brewer believes there is no substitute for cast iron. With a nine-cylinder engine it is possible to use a cam rotating in the direction of the crankshaft at 1/10 of the crankshaft speed, or in the opposite direction at ⅛ crankshaft speed. The author has found the best results with the former alternative and a valve contour suitable to operate both the exhaust and inlet valves without duplication of cam lobes. His cam is driven by a combination of planetary gearing and eccentrics, which sounds complicated but is said to be more simple than other mechanisms for the same purpose.

Discussion Brings Out Further Information

In the discussion, Mr. Brewer explained that the whole valve mechanism is immersed in oil as the oil is thrown from the center through the tubes shrouding the push-rods and fills the casing around the valve rockers. For that reason, it is advantageous to have the adjusting mechanism outside this casing. Valve-stem guides made from aluminum-bronze have been used for more than 200 hr. before showing much wear. They are made with larger clearance, and Mr. Brewer believes that this is largely taken up by carbon, accounting for the excellent wear.

To make up for the friction loss in the carbureter, there is an impeller rotating with a peripheral speed of 8400 ft. per min. At the radius of the carbureter inlet the linear speed of the impeller is 4300 ft. per min. The vanes are made on a logarithmic spiral more like a rotary air-compressor than an ordinary centrifugal blower. The weight of the engine is 455 lb., amounting to 2.8 lb. per hp.

Asked about the cost of this engine, Mr. Brewer stated that he hoped to be able to sell it for $2,000, but the price may be greater or less according to the quantities in which it is manufactured and the selling cost.

T. R. Crellin spoke of the cast cylinder as one of the most distinctive things about the engine. The manufacturing cost of this cylinder is about $10, while cylinders of another well-known air-cooled engine cost the Government $158 each. Another departure is the use of duralumin in the connecting-rods, making possible weights of about 5 lb. for the master rod and ½ lb. each for the link rods.

Officers Elected for Next Year

At this meeting the result of the letter-ballot election of Section officers for the coming year was announced as follows: Chairman, Adolph Gelpke; Vice-Chairman, John H. Geisse; Treasurer, O. M. Thornton; and Secretary, C. C. Trump.

Announcement was made that the Section would meet at the Philadelphia Cricket Club for a golf party on Wednesday, May 23.

At the close of the meeting, Charles O. Guernsey proposed a rising vote of thanks to Norman G. Shidle for his work as Chairman of the Section during the year just closed, and this was given with enthusiastic applause.

Wabble, Shimmy, and Tramp

Cleveland Section Studies Causes of and Remedies for Front-End Instability

BOTH theory and practice were invoked to solve the troublesome and knotty problems presented by the instability of the front end of an automobile, at the meeting of the Cleveland Section held May 14 in the grand ballroom of the Cleveland Hotel. The subject was analyzed by two speakers, J. F. Duby, of the Automotive Shop Equipment Co., and F. F. Chandler, of the Ross Gear & Tool Co. S. L. Bradley was chairman at this climax of the Section's successful season, and about 200 members and guests attended the technical session. An informal buffet luncheon was served afterward, and an excellent opportunity was thus afforded for social features. It was announced that the following members have been elected as officers of the Section for the coming year: Ferdinand Jehle, chairman; S. L. Bradley, vice-chairman; H. F. Sauer, treasurer; and Edwin L. Allen, Jr., secretary.

Causes of Front-End Trouble

Nothing can be gained by dwelling on the importance of careful, accurate testing and adjustment of the various parts of the front end of an automobile unless a definite decision can be reached as to what the proper settings should be, said J. F. Duby in his introductory remarks. It is high time, in his opinion, that a standard should be determined which will eliminate all the confusion existing on account of the wide differences of opinion of the various experts on front-end instability. Since there must be a cause for every mechanical movement, if the front end of an automobile generates movements that are undesirable the first step in eliminating the condition is to ascertain the cause of a particular movement, in place of putting a damper on to choke or deaden the movement.

The speaker first discussed the subject of camber, saying that the wheels are brought closer together at the bottom than at the top by changing the angle between the king-pin and the spindle. It is done principally to bring the bottom of the wheels more nearly in a direct line with the center line of the king-pin, thereby decreasing the tendency of the wheels to change their course when traveling through heavy mud or sand or when encountering road resistance of any sort.

In Mr. Duby's opinion toe-in has almost no influence on camber, and the slight influence it has is in the opposite direction to that commonly believed. It is often said that when the wheel is cambered it must also have toe-in because, when the wheel is slanting to one side, it is inclined to travel in a circle and toe-in overcomes this tendency. Mr. Duby agrees that the tendency to travel in a circle exists, but does not agree that toe-in overcomes this. At best, the wheels are being forced to travel in a straight line when their natural tendency is to travel in a circle, but the toe-in forces them to slide along slightly sidewise in addition to forcing them to travel in a straight line when their tendency is to travel in a circle. He also outlined the effect of camber on the tires.

Is Toe-In Really Necessary?

Analyzing some of the reasons that seem to necessitate toe-in, Mr. Duby said that a principal one is to compensate for the tendency of the wheels to spring the spindle backward while trav-

eling along the road. The common mistake in testing for toe-in is to fail to move the car forward before beginning the test. The front of the wheels should be pressed outward before any testing is done. If the steering connections are stiff the pressing outward on the wheels has little effect; but if the spindle arms are flexible or there is slight play in the bearings the pressing outward on the front of the wheels will bring them into approximately the position they would have when traveling on the road.

Quoting from a paper he wrote six years ago, the speaker stated that "if the king-pins were set out into the hub to bring them exactly into line with the center of the wheel, without slanting them outward at the bottom, no camber or toe-in would be necessary." Since then, great changes have been made in front-axle design, and he called attention to how nearly the condition he mentioned has been reached at present. In his opinion, the time has almost arrived when we can say that no toe-in is necessary.

Tire Wear and Shimmy

With high-pressure tires the contact between the tires and the road was so small that they would withstand considerable misalignment without serious results. With balloon tires the contact is much greater and it is therefore very important to keep the wheel alignment within a much narrower range of accuracy to prevent excessive wear. In view of these close limits, it is essential that an accurate means of testing for proper wheel alignment be provided, such as a wheel-aligning device.

In regard to shimmy, Mr. Duby defined the various contributory movements. The term "whip" is used to describe occasional but irregular turning of the steering-wheel in the hands of the driver. This usually results either from an improper drag-link setting or because of under-inflation of the tires. When the steering-wheel turns in the driver's hands regularly but slowly when traveling over a wavy road, the effect is termed "tramp." The turning of the front wheels violently from side to side at rapid regular intervals, regardless of whether this movement is transmitted through the steering-wheel, is termed "shimmy." This condition is usually brought about by excessive caster-angle, although there are many other contributing causes. The basic cause is usually the improper tilting of the axle, which controls the caster angle.

The speaker analyzed in detail just what occurs when a car is shimmying, giving an analysis also of so-called high-speed shimmying. Accurate means of testing axle and king-pin tilt are needed to work out the proper settings, and Mr. Duby described an axle-tilt gage designed for this purpose.

Cooperative Front-End Research Needed

Mr. Chandler said in part that he has yet to see a high-speed shimmy that is not preceded by axle tramp, and that he believes a large part of the movement is due to gyroscopic effect. Acceleration and deceleration of rotative speed about the front spindles also is a large factor. Unquestionably, he stated, the sidewise spring periods causing a reaction between the movement of the body mass and the turning of the wheels sets up terrific vibrations in the front end. In his opinion, one factor of instability is that purchasing departments are too much inclined to tell the engineering departments what must be used in vehicle construction. He suggested that joint research work be done by the axle, wheel, tire, spring and steering-gear manufacturers, because no individual has the time or money to assemble the equipment needed and conduct such research properly. One cause of front-end trouble, he believes, is that in some cases the plans of the engineering department are not followed, and he cited several instances of parts, such as those connected with the steering-gear, that were inaccurate by large fractions of an inch. He recommended that the engineers go into the shop and check up on whether the design is followed in practice, so that errors can be eliminated before the cars are completed.

Effect of Linking Front Springs

During the discussion following the papers, it was stated by Mr. Chandler in reply to a question that the linking of front springs on the forward end has been done primarily to make the movements of the front axle more uniform. This also tends to make the movements of the drag-link more nearly accurate so that there is less tendency to create road shock. He stated, however, that these practices are likely to increase the tendency to wander unless the shackles are bolted tight. In his opinion, the shackling of springs on the front end is an improvement provided the shackles are of a type that will permit servicing them to correct the lateral movement which will develop as a result of wear.

A. J. Scaife suggested that part of the front-axle tramp, so-called, is caused by the synchronism of the tire period and the spring period. He mentioned as one difficulty with regard to axle caster, which should be maintained within 1 or 1½ deg., the fitting of the vehicle with air springs on the front end and using different air-pressures, which may result in giving different degrees of axle caster.

Various phases of spring mounting, gyroscopic action and the like were discussed. Mr. Chandler mentioned that road sympathy is a factor of good steering-gear design. It is entirely feasible, he said, to design steering-gears that will absorb any tendency to make them reverse, but the cars would not be satisfactory to drive, as the steering-gear should retain just enough reversibility so that the driver can "feel" the road.

Tribute Paid to Lockhart

MEMBERS and guests of the Chicago Section stood with heads bowed, at the opening of the meeting held May 15, in silent tribute to the memory of Frank Lockhart, heroic racing driver who recently lost his life while attempting to break a speed record. He was to have been one of the speakers at the technical session, and

F. E. Moskovics

the fact that he was not present brought home with even greater force to those in attendance the great loss which the automotive industry had suffered because of his untimely and tragic fate. F. E. Moskovics, president of the Stutz Motor Car Co. of America, who also had been scheduled as a speaker and who was present, was so affected during his introductory remarks to his address to the Section by the tribute to Lockhart, that his voice faltered as he referred to his regret over the death of his close personal friend, and to his high regard for him as a man and engineering expert. One tribute he paid was to say: "There is no shadow of doubt that Lockhart was the greatest automobile driver of all time."

Engineering Lessons Learned by Racing

In the course of his address, Mr. Moskovics enumerated some contributions that racing has made to automo-

(*Concluded on p.* 736)

Standardization Activities

Plain and Lock-Washers

Definite Standardization Action Taken by Sectional Committee in Pittsburgh

ABOUT 2 years ago the organizing of a Sectional Committee for the standardizing of punched plain-washer and spring lock-washer sizes was undertaken by the Society and the American Society of Mechanical Engineers as sponsors under the procedure of the American Engineering Standards Committee. At that time another Sectional Committee was completing its work on screw and bolt heads and nuts, and, as standardization of washers necessarily depends to a large extent upon screw-head and nut dimensions, the Sectional Committee on Washers has not been active until recently. Some preliminary work was done last year by the Committee largely on the basis of the S.A.E. Standards that have been in use for many years. A more definite step was taken by the Sectional Committee, however, at a meeting held in Pittsburgh on May 17, at which C. W. Squier, representing the American Electric Railway Association, was elected chairman, and Fred Doepke, of the Wrought Washer Mfg. Co., was selected to serve as secretary.

Plain Washers

In general, the standardizing of plain washers does not present so much of a problem as that of lock-washers, as the former are in large measure punched from scrap material and do not require rolled sections of stock. It was pointed out at the meeting that to enable continued practice of using scrap material and because thickness requirements usually are not rigid, too close tolerance on thicknesses should not be set.

The Sectional Committee will restrict its work for the present to steel washers, but will probably consider washers of nonferrous metals and possibly wrought washers later on. To expedite the work, the following Subcommittee No. 1 on Plain Washers was appointed at the Pittsburgh meeting: C. R. Dowdy, of the Wrought Washer Mfg. Co., temporary chairman; G. A. Aiken, of the American Nut & Bolt Fastener Co.; A. H. Hoke, of the Pennsylvania Railroad Systems; R. H. Irons, of the Central Iron & Steel Co.; Wheeler Lord, of the Nicetown Plate Washer Co.; W. J. Outcalt, of the General Motors Corporation; G. K. Thompson, of the American Telephone & Telegraph Co.; O. B. Zimmerman, of the International Harvester Co., and a representative of the bureau of construction and repair, Navy Department.

Lock-Washers

Standardization of lock-washers is of greater interest, especially to the washer manufacturers, who are anxious to reduce the large number of rolled-steel sections they must carry at present to supply the large variety of lock-washer sizes to meet purchasers' demands. In discussing a preliminary proposal drafted by the Sectional Committee some time ago to reduce the standard to only one series of washers, by discontinuing the light and heavy series, it was recalled that probably 80 per cent of the lock-washers made are used by the automotive industry and that an investigation had shown that there is definite need for the present three series of sizes as included in the present S.A.E. Standards. It was suggested, however, that further investigation might show that the number of steel sections in the standards could be reduced for sizes larger than those used in quantity by the automotive industries, which sizes include bolt diameters up to about ⅝ in.

C. S. Clark, who represented C. H. Loutrel at the meeting, was appointed temporary chairman of Subcommittee No. 2 on Lock-Washers, other members being G. A. Aiken, of the American Bolt & Nut Fastener Co.; A. Boor, of the Willys-Overland Co.; H. B. Hird, of the bureau of engineering, Navy Department; A. H. Hoke, of the Pennsylvania Railroad Systems; C. H. Loutrel, of the National Lock Washer Co.; J. J. McBridge, of the American Car & Foundry Co.; W. J. Outcalt, of the General Motors Corporation; and O. B. Zimmerman, of the International Harvester Co. The Lock Washer Manufacturers' Association will be invited to designate four additional representatives on the Subcommittee.

In discussing the general programs of the Subcommittees, it was felt that the Subcommittees should be prepared to present at least preliminary reports to the Sectional Committee by next December, and that these reports should be based on canvasses made among the large washer-users as to their requirements and suggestions for a standard. It was felt that this should be done particularly in the case of lock-washers to determine the relative amount of use of the present three standard series of lock-washer sizes.

Nut-Slot Dimensions

IN an endeavor to bring about uniformity of nut-slot widths and depths in the various types of nut for which there are S.A.E. Specifications, a summary was made of the present dimensions and data gathered from nut manufacturers.

This information was submitted to a Subdivision of the Screw-Threads Division of the S.A.E. Standards Committee, and the chairman, K. L. Herrmann, of the Studebaker Corporation, has submitted the following table of proposed nut-slot dimensions for all classes of nut:

PROPOSED NUT-SLOT DIMENSIONS

Size, In.	Slot Width, In.	Slot Depth, In.
1/4	3/32	3/32
5/16	3/32	1/8
3/8	1/8	1/8
7/16	1/8	5/32
1/2	1/8	5/32
9/16	5/32	3/16
5/8	5/32	3/16
11/16	5/32	7/32
3/4	5/32	7/32
3/16	3/16	1/4
7/8	3/16	1/4
15/16	3/16	9/32
1	3/16	9/32
1⅛	7/32	5/16
1¼	7/32	5/16
1⅜	1/4	3/8
1½	1/4	3/8

Comments on and criticisms of these proposed dimensions may be sent to the Standards Department. The specifications are being sent to nut manufacturers for comment before being presented to the Screw-Threads Division.

License-Plate Bracket Slots

A RECENT communication from the Department of Commerce gives in considerable detail the results of a survey conducted with regard to motor-vehicle license-plates by the Department in the 48 States, the District of Columbia, Porto Rico, Alaska, Hawaii and the Philippine Islands. The data gathered relate to the length and width of plates, location of the legends on the plates, color combinations, frequency

of their use, and the mounting-slot dimensions.

Possibly the most interesting result of the survey is that it shows that for the first time all of the plates issued in all of the States and the aforementioned possessions of the United States fit the S.A.E. Standard License-Plate Bracket Slots. This means that a car fitted with a standard S.A.E. mounting bracket can be shipped to any place in these territories with assurance to the purchaser that his license-plates will fit the brackets without repunching, and also that the manufacturer furnishing the bracket can save cost through the standardization of his bracket-punching tools. The S.A.E. Standard is printed on p. 198 of the 1928 issue of the S.A.E. HANDBOOK.

Motorcoach Regulations

THE proposed Uniform Code for Motorcoach Specifications that was formulated by a Special Committee on which the Society was represented and the principal part of which was printed in the April, 1928, issue of THE JOURNAL, p. 477, was the subject of consideration at a meeting of the Motorcoach Division of the Society's Standards Committee in Detroit on May 11. One of the major changes recommended in the report was the inclusion of a definition for a type of motorcoach rapidly coming into use for suburban service that follows the constructional features of the parlor-car type, but has sufficient headroom for carrying a limited number of standing passengers. The definition recommended is:

> A Suburban-type Motorcoach is one designed with longitudinal aisle and cross-seats and providing for a limited number of standing passengers.

It was also recommended that the present descriptive name for the Observation Parlor-Car type be changed to Raised-Deck Parlor-Car, as it is common practice to call the conventional single-deck parlor-car with large plate-glass rear-windows, a grill and reversed seats in the rear, an observation parlor-car.

SOME RULE MODIFICATIONS RECOMMENDED

The recommended inclusion of the suburban type resulted in modifying Rule 5 for the minimum headroom dimensions by changing the first item under this rule, City-Type Buses—76 In., to read City and Suburban-Type Buses (Single-Deck)—76 In. Also, under this rule it was recommended that provision be made for a minimum height for motorcoaches of the double-deck city-type in which standees are not permitted by providing that the minimum height of the lower deck for the double-deck city-type with standees be 76 in. and adding the minimum height of 70 in. for the lower deck of the double-deck city-type without standees.

It was recommended that under Rule 11, Emergency Doors, exception be made for motorcoaches having a rear-ward service-door.

Under Rule 17, which relates to stop-signal lights, it is very strongly recommended that the provision for automatically operating the stop-signal light on the release of the clutch be omitted, as this is obviously unnecessary, and stop-signals so operated would be very misleading to following vehicles.

It was also recommended that Rule 29 on Bumpers provide for securely attaching the rear bumper but not necessarily to the chassis frame, as other methods are in common use. Inasmuch as other means than a muffler might be suitably provided for muffling the exhaust, it was recommended that Rule 31, Mufflers, should read that "means be provided for quieting the exhaust" rather than that a muffler be required.

A number of other minor modifications in the proposed rules of the Code were also recommended.

ONLY A STEP IN PROGRESS.

The action taken by the Motorcoach Division is only a further step in progress, as the Committee that formulated the Code intends to review recommendations regarding it that will be submitted by other National organizations to which the Code was referred, so that what it is hoped may be a final draft can be worked out. When this is done, the Motorcoach Division will again review these rules with the purpose of revising the present S.A.E. Motorcoach Specifications printed on p. 525 of the 1928 issue of the S.A.E. HANDBOOK.

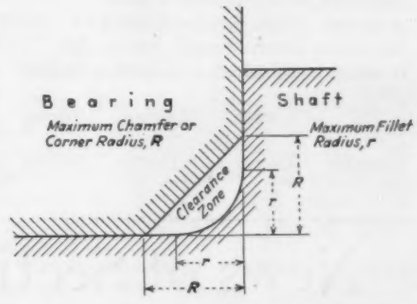
Ball-Bearing Corner-Radii

Progress Report Submitted at This Time as to Program of Ball and Roller-Bearings Division

IN April, 1926, the Sectional Committee for the Standardization of Ball Bearings that is sponsored by the Society and American Society of Mechanical Engineers under the procedure of the American Engineering Standards Committee worked out, in cooperation with the Ball and Roller-Bearings Division and also the National standardizing bodies of European countries, tables of annular ball-bearings in which the maximum fillet-radii for the bearing shafts and housings and the corner radii for the bearings were included. These differ from the specification of the minimum corner-radius given in the S.A.E. Standard, in which the corner radius is defined as "the maximum fillet on the shaft or in the housing which will be cleared by the bearing."

The recommendation of the Sectional Committee was approved by the bearing manufacturers at that time, but the revision of the S.A.E. Standard to conform to the recommendation was held in abeyance because it was thought that further developments in the international standardization program might alter the situation. This part of the international program, which is an informal one so far as American interests are concerned, has been tentatively accepted by the American bearings manufacturers for the proposed American Standard now nearing completion in the Sectional Committee.

At a meeting of the bearings manufacturers in New York on April 24, it was decided to continue their study of the various factors affecting the manufacture of bearings. So far as corner radii are concerned, it was agreed that the bearing corner-radii specified should be maximum rather than minimum to provide a zone, as shown on the accompanying illustration, in which any corner radius fall-



Bearing Widths mm. (incl.)	Maximum Shaft Fillet-Radii—r		Maximum Bearing Corner-Radii—R	
	mm.	Inch	mm.	Inch
5— 6	0.4	0.016	0.5	0.020
7— 8	0.4	0.016	1.0	0.039
9—11	0.6	0.024	1.0	0.039
12—14	1.0	0.039	1.5	0.059
15—20	1.0	0.039	2.0	0.079
21—25	1.5	0.059	2.5	0.098
26—30	2.0	0.079	3.0	0.118
31—39	2.0	0.079	3.5	0.138
41—50	2.5	0.098	4.0	0.157
52—54	3.0	0.118	5.0	0.197

ing therein can be used by the bearing manufacturers without causing interference.

In the original proposal of the American Standard, the bearing corner-radius for the 4 and 5-mm. bore sizes was 0.6 mm., but this has been found too large and was consequently changed to 0.5 mm.

The Ball and Roller-Bearings Division submits this progress report at this time with the purpose of submitting final recommendations to the Standards Committee for adoption by the Society at the Annual Meeting next January. In the meantime, suggestions helpful to the program, and especially regarding the corner radii, are desired.

Progress Report

The Ballard Roller Bearings Division is proceeding on the basis that the Maximum Fillet-Radii for Shafts and Housings and Maximum Corner-Radii (Chamfer) for Ball Bearings, should apply to the following series of bearings in the present S.A.E. Standard, commencing on p. 212 of the 1928 issue of the S.A.E. *Handbook*, as shown in the accompanying table.

Annular, Light Series (200)
Annual, Medium Series (300)
Annular, Heavy Series (400)
Annular, Wide Series (5200)
Annular, Wide Series (5300)
Annular, Wide Series (5400)
Annular, Extra Small (30 to 39)
Angular Contact, Light Series (7200)
Angular Contact, Medium Series (7300)
Angular Contact, Heavy Series (7400)

Head-Lamp Lenses Revised

New Table Provides for Wide-Flange and Narrow-Flange Types

A SUBDIVISION of the Lighting Division, under the chairmanship of W. M. Johnson, of the National Lamp Works, Nela Park, Cleveland, has been studying the present S.A.E. Head-Lamp Lens Specifications with a view to revising these standards.

A new table of outside diameters and diameters of prismatic areas is embodied in the report, which provides for two types of lens, one with a wide and the other with a narrow flange. The illustration and table published herewith comprise the proposed S.A.E. Standard on Head-Lamp Lenses as it will be submitted to the Lighting Division for approval.

The specifications are also being submitted to lens and lamp manufacturers for comment and criticism.

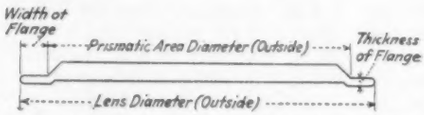
It will be appreciated if members interested in these specifications will write their comments to the Standards Department so that they can be considered when the Division discusses this subject.

Head-Lamp Lenses

(*S.A.E. Standard*)

This standard applies only to motor-vehicle electric head-lamp lenses. The thickness of the lens flange for all sizes of head-lamp lenses shall be 5/32 in. at the edge of the prismatic area and 1/8 in. at the edge of the lens, with tolerances of plus 1/64 in. and minus 0.

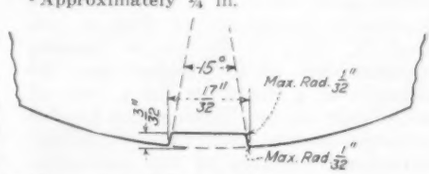
One lens locating notch 17/32 in. wide and having a minimum depth of 1/8 in., as specified in the drawing, shall be located at the bottom of all except plain head-lamp lenses.



HEAD-LAMP LENS AND PRISMATIC AREA DIAMETERS

Outside Diameter, In.		Diameter of Prismatic Area, Sq. In.	
Wide Flange[1]	Narrow Flange[2]	Maximum	Minimum
8.00	7.50	6.980	6.955
8.25	7.75	7.230	7.205
8.50	8.00	7.480	7.455
8.75	8.25	7.730	7.705
9.00	8.50	7.980	7.955
9.25	8.75	8.230	8.205
9.50	9.00	8.480	8.455
9.75	9.25	8.730	8.705
10.00	9.50	8.980	8.955
10.50	10.00	9.480	9.455
11.00	10.50	9.980	9.955
11.50	11.00	10.480	10.455
12.00	11.50	10.980	10.955
12.50	12.00	11.480	11.455
13.00	12.50	11.980	11.955

[1] Approximately 1/8 in.
[2] Approximately 1/4 in.



News of Section Meetings

(*Concluded from p.* 733)

tive engineering. Many of the ideas first put into practice in racing cars have since been incorporated as a feature of passenger-cars, he said. Among these he mentioned the development of tires, demountable rims which facilitate tire changes, improvement in fuel, better lubrication of engine cylinders, and more effective carbureters. The use of supercharging, and the introduction of a device termed an "inter-cooler" are now being developed from racing-car experience. Better steering-control has also been developed from such experience, he said. Mr. Moskovics then related some of his experiences in connection with racing, and cited in greater detail the engineering features which later have been improved.

Section officers for 1928-1929 are: J. W. Tierney, chairman; D. P. Barnard, vice-chairman; L. W. Oldfield, secretary; G. A. Buckbee, treasurer.

Section Meeting at Purdue

ONE hundred and fifty members of the Indiana Section closed the regular meetings season with a meeting at Purdue University, in Lafayette, Ind., on May 19. The day was spent in inspecting the latest types of automotive-research and testing apparatus in the laboratories of the university and observing demonstrations of it; in attending a ball game between Purdue and Northwestern Universities or the State collegiate track meet.

Factors affecting combustion in Diesel engines and their efficiency were discussed in an address by Prof. A. E. Hershey, of the University of Illinois. William M. S. Jackson and Paul F. Hackethal, consulting engineers of Detroit, gave a joint paper on Four Years' Research in the Light-Weight High-Speed Diesel-Engine Field.

The Value of Racing

RECOUNTING his many experiences in automobile racing, Wade Morton, of the Auburn Motor Co., told members of the Washington Section, at their meeting at the Racquet Club on May 25, of the great value of racing to all automobile users. He explained how lessons learned in racing had led to the development of numerous materials of better grade and to improvements in the design of engines and chassis units. Mr. Morton emphasized particularly the importance of stock-car contests. Discussion following his address included points regarding carbureters and manifolding, with reference especially to eight-cylinder engines, and to the timing methods used in races.

Section officers elected for next season were announced as follows: T. P. Neill, chairman; G. O. Pooley, vice-chairman; G. E. Reynolds, treasurer, and E. S. Pardoe, secretary.

A speakers' dinner preceded the technical session.

Personal Notes of the Members

Signal Honor for E. P. Warner

Edward P. Warner, Assistant Secretary of the Navy, has been awarded the medal of the Aero Club of France for the best technical work on aeronautical engineering for 1927. The technical work for which Mr. Warner received the medal is his book, Aerodynamics, the first volume of a series on airplane design. Readers of THE JOURNAL will recall that a review of this book appeared in the November, 1927, issue.

This new honor that has come to Secretary Warner will have a particular interest for a large number of members of the Society who have known him as a very active participant in the Society's affairs since his election to Member grade in 1917. He was Second Vice-President, representing aviation engineering, in 1923, and was a Councilor in 1925 and 1926. His committee work has included the chairmanship of the Publication Committee for 5 years; the chairmanship of the Aeronautic Division of the Standards Committee for 3 years; and membership at various times on the Meetings, Sections and Research Committees. He is a member of the Washington Section and was for several years a member of the New England Section, having been Vice-Chairman of the latter in 1925. His chairmanship of the 1927 Aeronautic Meeting Committee was largely responsible for the distinguished success of the meeting that year, and his presence on the committee that is planning the 1928 Aeronautic Meeting augurs well for that event.

Several of Secretary Warner's contributions to aeronautical literature were presented by him at National and Section meetings, and have been published in THE JOURNAL as follows: Commercial Aviation in the Eastern Hemisphere, August, 1921; Airplane Performance Formulas, June, 1922; The Design of Commercial Airplanes, February, 1923; Commercial Aviation in 1923, April, 1924; Cooperation in Aircraft Design, November, 1926; Service Aviation, Aeronautical Engineering and Commercial Aviation, August, 1927; and Application of Non-Military Aircraft to Naval Purposes, November, 1927.

Mr. Warner's connection with the Society is characterized by unfailing enthusiasm and willingness to cooperate in everything pertaining to the welfare of the organization. For that reason, a mere enumeration of the Society offices that he has held, the committees of which he has been chairman or member, and the papers that he has presented can convey no adequate idea of the value and extent of his services to the Society.

Towle Joins General Motors

H. Ledyard Towle, who has been in charge of the Duco color advisory service since 1926, on June 1 became a member of the art and color section of the General Motors Corporation. Prior to his connection with the Duco service, he was successively associated in the capacity of art director with the H. K. McCann Co., Frank Seaman, Inc., and the Campbell-Ewald Co.

In the course of his distinguished

H. LEDYARD TOWLE

career as an artist, Captain Towle has in turn been portrait painter, mural decorator and instructor of art. Portraits form a most interesting part of his work, many of these having merited the honor of a place in institutions such as the Municipal Building, New York City; Ohio Wesleyan University; the National Gallery in the City of Washington; and the Museum of Fine Arts, San Francisco. He was awarded first prize for the best portrait by the Connecticut Academy of Fine Arts in 1920.

Captain Towle has been an Associate Member of the Society and a member of the Metropolitan Section since 1926. His paper entitled Color Harmony in the Automotive Industry was an interesting feature of the Society's 1926 Annual Meeting. Members who are planning to attend the 1928 Summer Meeting in Quebec will be glad to know that Captain Towle is chairman of the Body Design Session.

Ford and Lawrance Receive Medals

Two members of the Society, Henry Ford and Charles L. Lawrance, were included in a group of 16 men whose notable scientific achievements were recognized by the Franklin Institute by the award of medals on May 16 in Philadelphia. The Society membership of both of these distinguished men dates back to 1905.

The Cresson Medal was awarded to Mr. Ford "in consideration of his rare inventive ability and power of organization, by means of which he was able to effect high-speed production of automobiles, revolutionizing the industry, and his outstanding executive powers and industrial leadership."

Mr. Lawrance received the Cresson Medal for his development of the air-cooled aircraft engine.

Francis Holds New Position

D. D. Francis has become president and treasurer of the Wheeler-Schebler Carburetor Co., of Indianapolis. In accepting this position, he brings to an end an affiliation of 7 years with the Marvel Carburetor Co., of Flint, Mich.

Upon completion of an engineering course at the United States Naval Academy, Mr. Francis served in the United States Navy for 3 years. He first became associated with the Marvel Carburetor Co. as assistant superintendent in 1921, and was later promoted to the position of secretary-treasurer.

Mr. Francis has been an Associate Member of the Society and a member of the Detroit Section since 1924.

Stratford Organizes a Company

Charles W. Stratford has organized the Stratford Engineering Co. in Kansas City, Mo., his native city. This company will be concerned with the design, manufacture, sale, erection and initial operation of petroleum-refining equipment, a field that has been explored thoroughly by Mr. Stratford.

After receiving his degree of Bachelor of Science from Knox College in 1903, Mr. Stratford was successively

(*Continued on p. 34*)

Applicants Qualified

The following applicants have qualified for admission to the Society between April 10 and May 10, 1928. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (S M) Service Member; (F M) Foreign Member.

ALFARO, HERACLIO (M) aeronautic engineering, 2440 Overlook Road, *Cleveland Heights, Ohio.*

ALMEN, H. V. (M) project engineer, General Motors Corporation, Room L-306 General Motors Building, *Detroit.*

ALMQUIST, ERIC GUSTAF (J) draftsman, Curtiss Aeroplane & Motor Co., Inc., *Buffalo;* (mail) 114 Herkimer Street.

ANDERSON, RALPH F. (J) estimator and engineer, A. & J. Iron Works, *Chicago;* (mail) 1624 Edgewater Avenue.

BAILEY, ALFRED (A) director of overseas sales, Ferodo Ltd., Chapel-en-leFrith, via Stockport; (mail) "Parkfield" Carlisle Road, *Buxton, England.*

BALASHOFF, NICHOLAS V. (M) aeronautic engineer, Bellanca Aircraft Corporation, Staten Island, N. Y.; (mail) 14 West 64th Street, *New York City.*

BAZATA, JOSEPH F. (A) spark-plug development engineer. Moto-Meter Co., Inc., Long Island City, N. Y.; (mail) 39-35 Sixty-fifth Place, *Woodside, N. Y.*

BEAUCHAMP, ROBERT B. (A) time-study, tools and equipment engineer, F. B. Stearns Co., Cleveland; (mail) 2071 Deanwood Avenue, *East Cleveland, Ohio.*

BENCKE, ALBERT ERIC (A) courtesy manager, Austral Motors, Ltd., Brisbane, Queensland, Australia; (mail) "Nemilcrest" Norman Street, *Annerley, Brisbane, Queensland, Australia.*

BLOMSTROM, LOWELL C. (M) assistant chief engineer, Federal-Mogul Corporation, 11031 Shoemaker Avenue, *Detroit.*

BLOOMFIELD, JOHN J. (J) research laboratory assistant, Studebaker Corporation of America, *South Bend, Ind.;* (mail) 518 South Columbia Street.

BOALS, R. B. (M) assistant professor, department of mechanical engineering, Oregon State College, *Corvallis, Ore.;* (mail) 146 North 21st Street.

BOHRMAN, IRVING GEORGE (J) draftsman, Waukesha Motor Co., *Waukesha, Wis.;* (mail) 229 Waverly Place.

BOLAND, JOSEPH J. (M) designer, Aeromarine Co., *Keyport, N. J.;* (mail) Warren and Osborn Streets.

BOTKIN, CLAUDE E. (A) supervisor of inspection, Richfield Oil Co., Los Angeles; (mail) 951 Sixteenth Street, *Hermosa Beach, Cal.*

BOYNTON, ELLIS S. (A) branch manager in charge of sales, Kings County Buick Inc., *Brooklyn, N. Y.;* (mail) 354 East 21st Street.

BRANCH, HARRY C. (M) technical service engineer, Leece-Neville Co., 5365 Hamilton Avenue, *Cleveland.*

BRETT, HENRY, JR. (M) developmnt manager, Kelly-Springfield Tire Co., *Cumberland, Md.*

BROWN, H. FLETCHER (M) chief engineer, Eagle Iron Works, Des Moines, Iowa; (mail) P. O. Box 135, *Fort Des Moines, Iowa.*

BURNS, THOMAS (A) mechanic in charge, Department Street Cleaning, Borough of Queens, New York City; (mail) 55-46 96th Street, *Elmhurst, N. Y.*

CAMPBELL, E. EARL (M) experimental engineer, Chrysler Corporation, *Detroit;* (mail) 15099 Monte Vista Avenue.

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Applicants for Membership

The applications for membership received between April 16 and May 15, 1928, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ANDERSON, HAROLD CARL, assistant service manager, Gas & Oil Engine Service Co., *New York City.*

ATHERTON, HAROLD S., district manager in charge of car equipment business, Whitaker Battery Supply Co., *Kansas City, Mo.*

BAKER, HENRY G., vice-president, Baker Machinery Co., *Des Moines, Iowa.*

BERNIER, ARTHUR, service-station foreman and service engineer, Standard Cab Co., *Montreal, Que., Canada.*

CHANG, K. H., student, State College of Washington, *Pullman, Wash.*

CLARK, CHARLES S., sales department, National Lock Washer Co., *Newark, N. J.*

CONDIT, W. CHAPIN, student engineer, H. H. Franklin Mfg. Co., *Syracuse, N. Y.*

CORD, E. L., president, Auburn Automobile Co., *Auburn, Ind.*

COX, RAYMOND J., student, Newark College of Engineering, *Newark, N. J.*

DAVIS, RODGER W., draftsman, shock insulator design, International Motor Co., *Long Island City, N. Y.*

DOYLE, JOHN M., assistant factory engineer, White Motor Co., *Cleveland.*

DYER, RAYMOND W., standards department, Durant Motors, Inc., *Elizabeth, N. J.*

ENGLER, JOE, manager, Joe Engler, *Seattle.*

FEHR, ROY B., director of the laboratory, Copland Gear Lapping Syndicate, *Detroit.*

FOWLER, WILLIAM JAMES, draftsman, Edward G. Budd Mfg. Co., *Detroit.*

FRAZER, J. W., sales manager, Chrysler Sales Corporation, *Detroit.*

FREE, FRANK, district manager, Cadillac Motor Car Co., *Detroit.*

FRENCH, M. C., lubricating sales engineer, Union Oil Co. of California, *Los Angeles.*

GAFFKE, WILLIAM J., foreman, Houdaille Engineering Co., *Buffalo.*

GARDINER, GEORGE WILLIAM, superintendent, Brake Service Co., *Los Angeles.*

GARDNER, HAROLD B., assistant to resident vice-president, Westinghouse Air Brake Co., *New York City.*

GLASS, PHILIP A., Detroit representative, Federal Bearings Co., Inc., *Poughkeepsie, N. Y.*

GOODWIN, WILLIAM GEORGE, chief chemist, Dayton Rubber Mfg. Co., *Dayton, Ohio.*

GREEN, ROLLAN A., vice-president and general manager, Graham-Paige Co. of New England, *Boston.*

HECTOR, EDWARD G., junior draftsman, Houde Engineering Corporation, *Buffalo.*

HESS, ERNEST E., designing engineer, Lufkin Foundry & Machine Co., *Lufkin, Tex.*

HOMS, JOSE M., export manager, Pablo Homs, Inc., *New York City.*

JENKINS, EDWARD S., production aeronautical engineer, Curtiss Aeroplane & Motor Co., *Buffalo.*

KAMPE, J. LOUIS, sales engineer, L. A. Young Spring & Wire Corporation, *Detroit.*

KING, ARTHUR W., general superintendent of assembly division, Willys Overland Co., *Toledo.*

KINNEAR, HARRY D., sales manager of factory equipment, Gabriel Snubber Mfg. Co., *Cleveland.*

KUEHN, OTTO, laboratory assistant and instructor, Armour Institute of Technology, *Chicago.*

LAMBERT, ARTHUR J., service manager, Garford Motor Truck Co., Inc., *Mount Vernon, N. Y.*

LANGER, KONRAD, designer, Brooks Steam Motors, Inc., *Buffalo.*

MAULSBY, F. P., superintendent of motor-vehicle equipment, American Railway Express Co., *San Francisco.*

MCBRIDE, E. F., assistant to manager of purchases, Richfield Oil Co., *Los Angeles.*

MCCUE, NORBERT D., assistant superintendent of transportation, Great A & P Tea Co., *Chicago.*

MCNAMARA, LIEUT. JAMES H., Adjutant General's Office, New York State Arsenal, *Brooklyn, N. Y.*

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MEYERS, LEE D., JR., partner, Aircraft Engineering Co., *Los Angeles.*

MIDDAUGH, CLIFFORD J., plant construction miscellaneous engineer, General Electric Co., *Fort Wayne, Ind.*

MILLER, HERMAN C., service promotion and field representative, Olds Motor Works, *New York City.*

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MILLER, SCOTT G., chief engineer, Consolidated Coach Corporation, *Lexington, Ky.*

MUNROE, WALTER L., student, Franklin Union Technical Institute, *Boston.*

NOVAK, J. N., draftsman, Winton Engine Co., *Cleveland.*

OLTMANNS, A. M., engineer, Vacuum Oil Co., *New York City.*

PINNER, W. L., chemical engineer, C. G. Spring & Bumper Co., *Detroit.*

PODVIN, A. F., general sales manager, Northwestern Oil Co., *Superior, Wis.*

POND, JOHN ENOCH, consulting and designing engineer, Motive Devices, Inc., *San Francisco.*

POST, GEORGE B., manager, Keystone Aircraft Corporation of New York and president, Free Bottom Craft, Inc., *New York City.*

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THORNE, WARD, assistant superintendent, Mechanical Mfg. Co., *Chicago.*

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Notes and Reviews

AIRCRAFT

Everybody's Aviation Guide. By Victor W. Pagé. Published by the Norman W. Henley Publishing Co., New York City. 247 pp. 140 illustrations. [A-1]

This guide endeavors to present, in a simple and concise style, the knowledge that the average person desires about all phases of aircraft construction and operation. It contains 600 questions and answers grouped in a brief but practical series of lessons logically arranged and easily understood. Many of the numerous diagrams and photographs accompanying the text have been especially prepared to simplify the subject matter for the layman.

The author takes the reader from the elementary conceptions of mechanical flight and primitive forms of aircraft to a more advanced consideration of aerodynamic principles. He succeeds in doing this by (*a*) outlining briefly the early aeronautical history, (*b*) analyzing the construction of various types of airplane, and (*c*) presenting the principles by which flying craft navigate the air.

Other phases discussed are: (*a*) water and air-cooled types of airplane engines, and (*b*) the relation of airplane parts to one another and their functions. Simplified explanations are given of the theory of flight and how aircraft are controlled.

This book will attract the practical rather than the technical reader. It will appeal, not only to the person beginning to study aviation, but to the shopman or garageman who wishes to start the study of aeronautics to be prepared to enter this new and rapidly developing field.

The Constructional Design of Metal Flying-Boat Hulls. By F. Langley. Published in *The Aeroplane*, March 28, 1928, p. 423. [A-1]

The point of view of the naval architect rather than that of the aerodynamic expert is maintained in this paper.

Magnesium and beryllium alloys and Alclad are mentioned in the section on materials as possible future rivals of duralumin. Under the heading of scantlings, suggestions are made for the materials and methods of construction to be employed in a typical 45-ft. hull, to be built in duralumin, with longitudinal shell-plating and framed on the principle of the Isherwood airships.

Steel fittings, riveting, butts and laps are also dealt with briefly.

The Problem of the Long-Range Flying Boat. By J. D. Rennie. Published in *The Journal of the Royal Aeronautical Society*, April, 1928, p. 264. [A-1]

One of the beneficiaries of the transatlantic flight disasters has been the flying-boat, which has gained many partizans, more or less well informed, as the suitable craft for long-range overseas transportation. The author, who has carried out much research on this type of vessel and who designed the largest one ever built, proposes in this article to arrive at a true evaluation of its possibilities, and to show the factors that must be considered carefully in the designing of a long-range flying-boat operating under known weather and sea conditions.

The author devotes much attention to the seaworthiness of flying-boats and presents a number of considerations that affect the ability to alight on and take off from the water. In connection with air performance, he discusses the effect on range and cruising speed of aspect ratios, the take-off speed and the top speed. He shows how the range may be increased by improved throttled-engine consumption and recommends for serious consideration the advantages of the three-engined boat.

Le Carburateur d'Aviation. By Léon Poincaré. Published in *La Technique Moderne*, March 15, 1928, p. 217. [A-1]

Carbureters for land-transportation engines must furnish correct fuel-air mixtures for a wide range of engine operation at virtually constant altitude. Airplane carbureters function for comparatively unchanging engine régimes but through widely varying altitudes. The latter should therefore be fashioned on entirely new lines instead of being, as they are now, only slightly modified copies of their earlier motor-vehicle prototypes.

With this as his thesis, the author points out what seems to him the road toward progressive aircraft-carbureter design. Designers should first provide for automatic compensation with changes in altitude, dealing with automatic functioning at a fixed altitude as an auxiliary problem which may be solved by a mechanical control.

As a suggestion, suppose that a nozzle is used the discharge from which is proportional to the depression in the venturi. Then, if it is granted that, with a fixed engine-speed and throttle opening, the volume of air breathed in remains constant with variations in altitude, the depression in the venturi will be proportional to the air density, the mass of both air and fuel will be proportional to the depression in the venturi, and the richness of the fuel-air mixture will be independent of altitude; in other words, the carbureter will be automatically compensating in this respect.

A few words on the complications introduced by supercharging concludes this clearly reasoned analysis of aircraft-engine carbureter action.

Aircraft Yearbook, 1928. Published by Aeronautical Chamber of Commerce of America, Inc., New York City. 551 pp.; 246 illustrations. [A-3]

When, after another decade or so of aeronautical history, 1927 is looked back upon, will it have shrunk in proportion with the gradually receding perspective, or will it still stand forth, as it seems to us now, as a prodigy of achievement? The answer will depend largely on the accomplishments of succeeding time; but certainly the epochal events of the 12 months just past seem sufficiently important to us of today to merit a record that is thorough and accurate, yet sufficiently concise to be made widely available.

Such a record is furnished by the Aircraft Yearbook, which reviews aeronautics in this Country, both Governmental and civil, recounts the important flights of 1927, surveys the progress of aviation in other countries, and deals briefly with both the technical and industrial developments in aircraft.

The volume is no less valuable as a handbook of reference for current use. Information and statistics on almost every phase of the present aeronautic world are condensed in an appendix. A

(*Continued on next left-hand page*)

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

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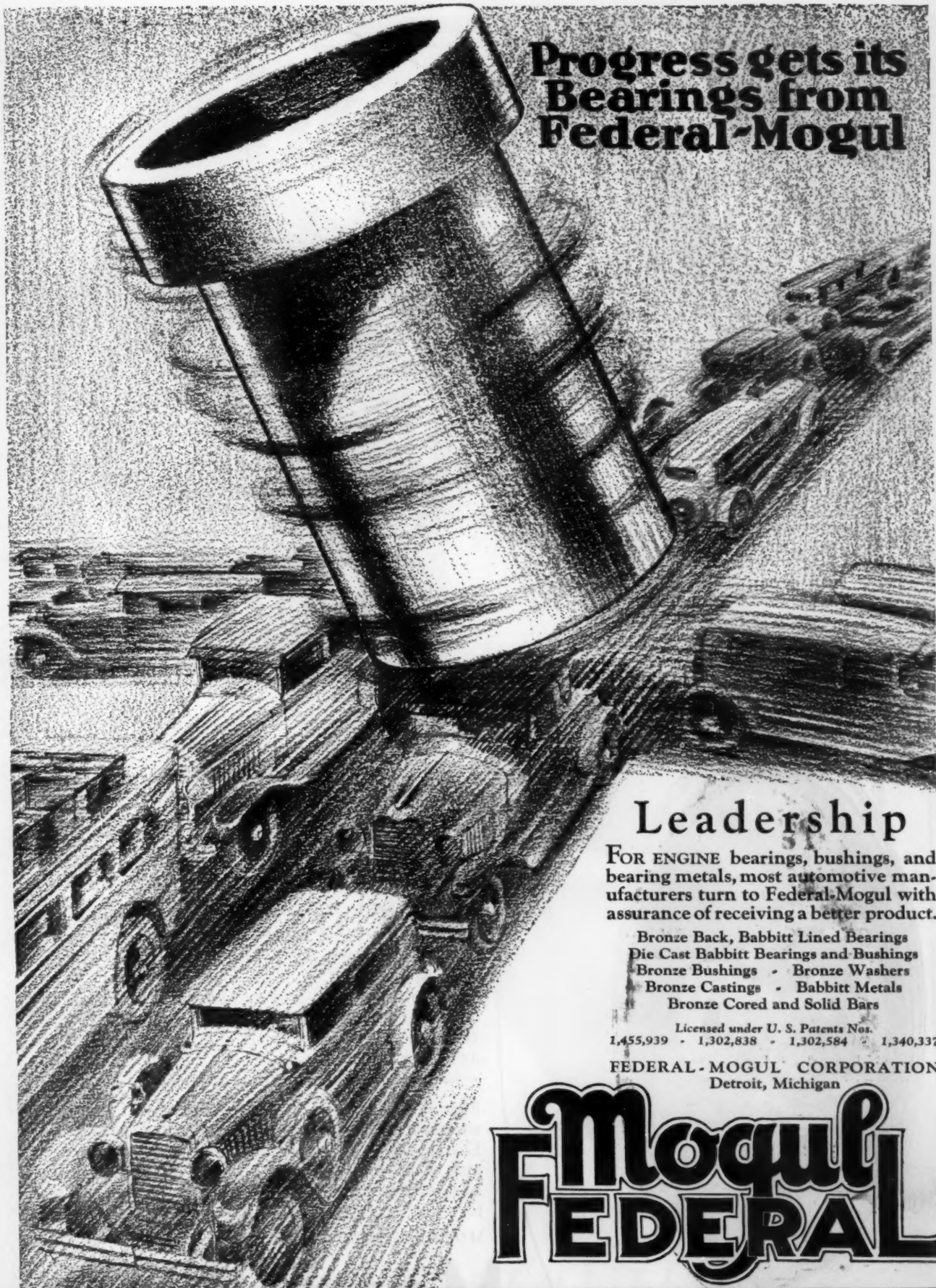

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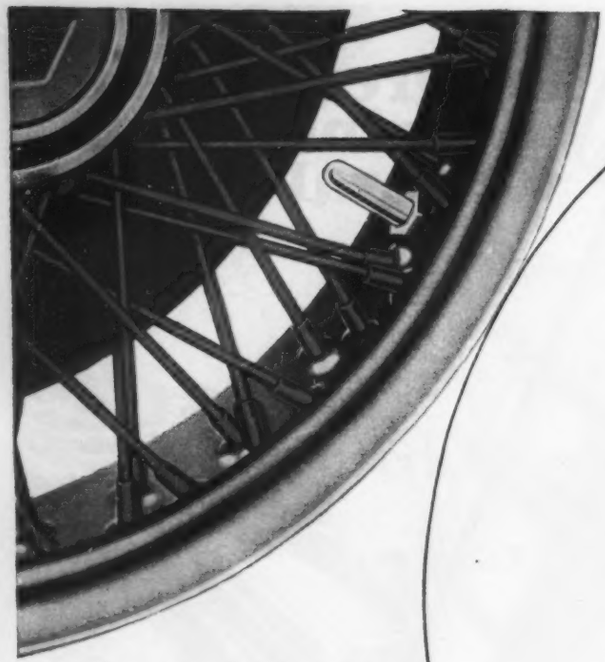

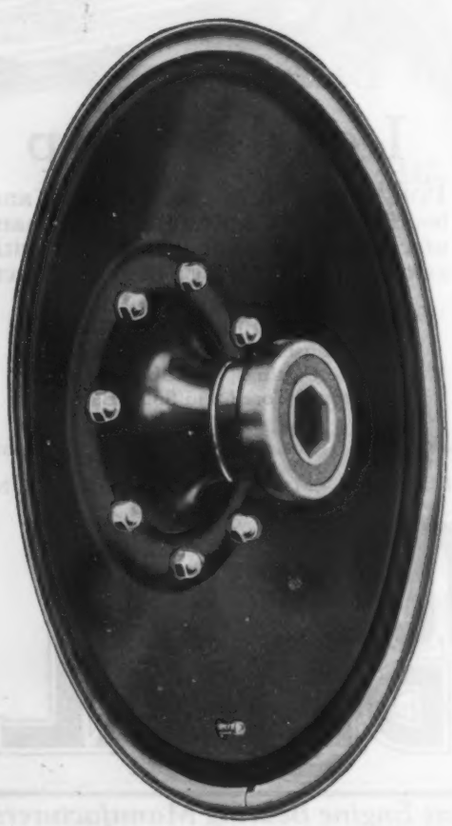

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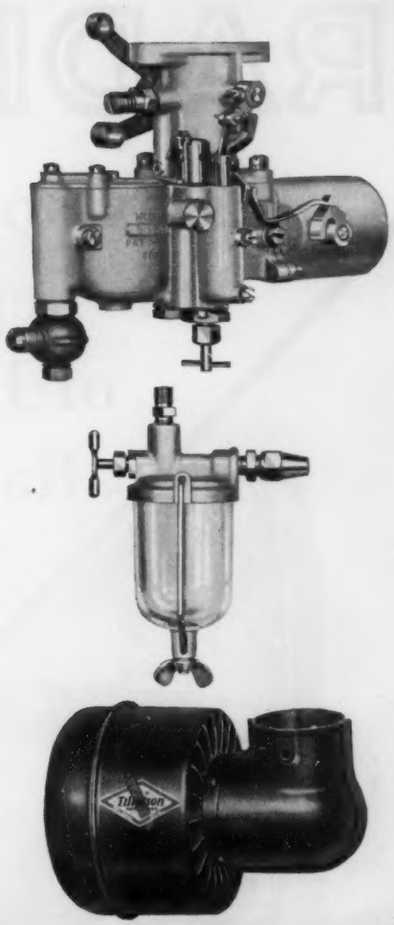

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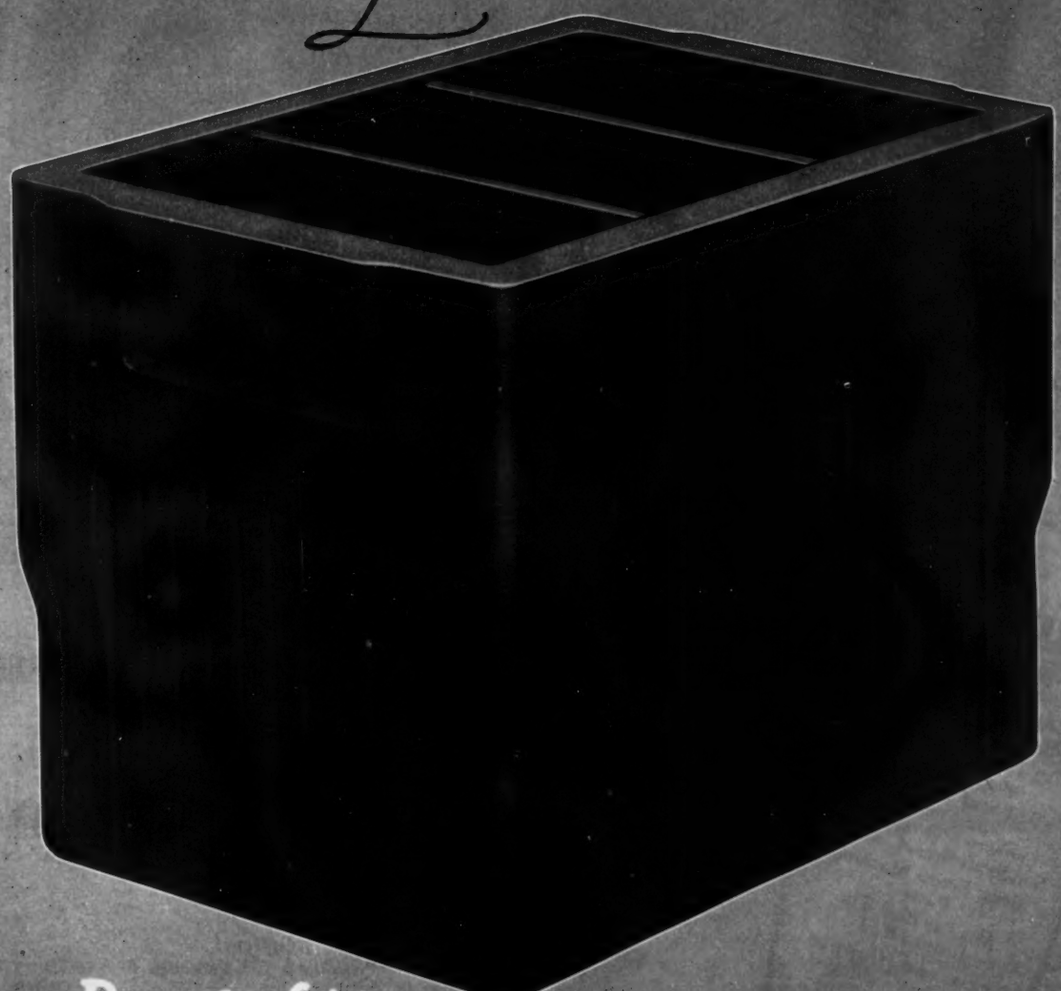

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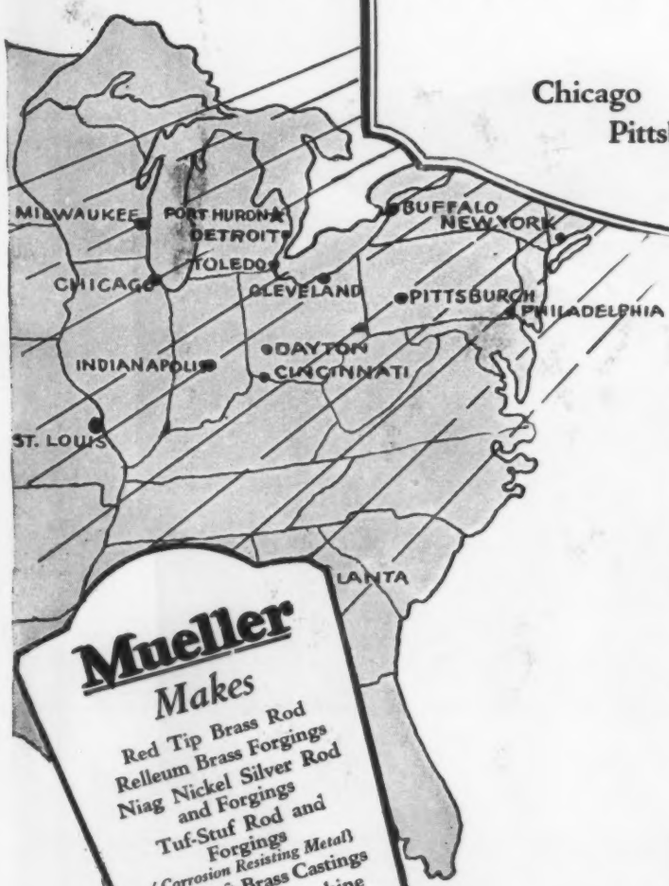

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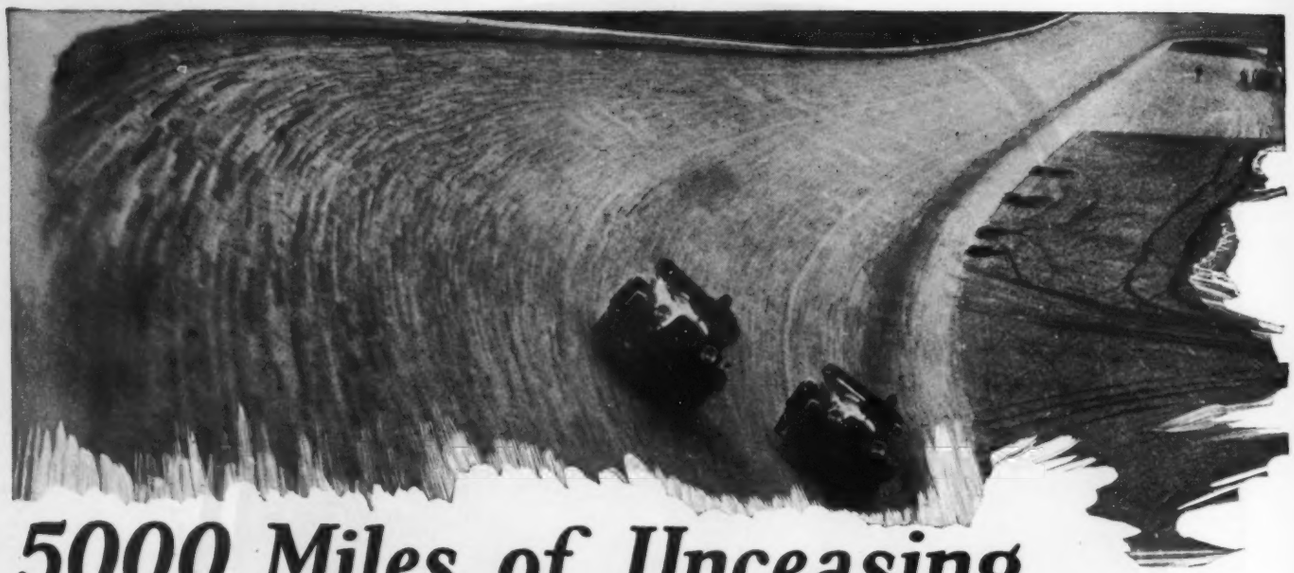

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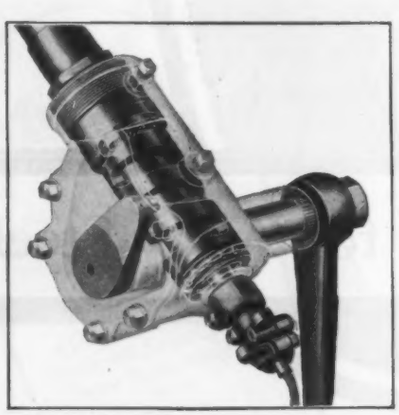

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- ☐ Methods of Obtaining Greater Power from Engines Than Formerly—T. J. Litle, Jr., Marmon Motor Car Co.
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- ☐ The Basic Appeal of the Motor-Car to Women with Relation to Body Lines and Interior Trimming—Paul Thomas, Style Expert and Sales Promotion Manager, Cheney Brothers Co.
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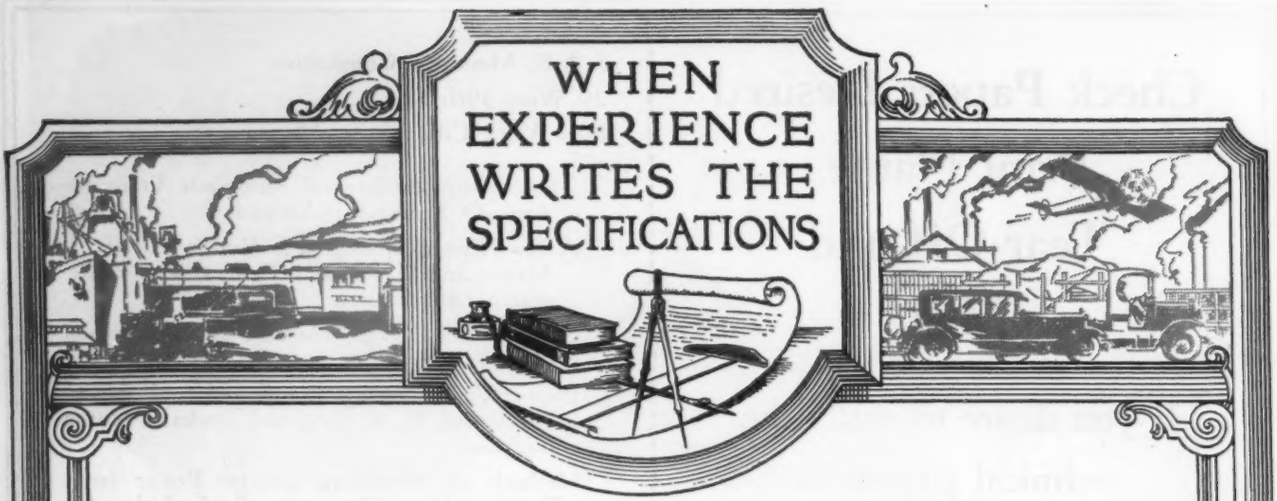

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NICKEL ALLOY STEEL PARTS OF CURTISS D-12 ENGINE

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THE First Pursuit Group, U. S. Army Corps, equipped with Curtiss "Hawks", powered by Curtiss D-12 Engines, is the crack Pursuit Group of the U. S. Army Air Corps. Nineteen of these pursuit planes recently made a flight from Selfridge Field, Detroit, to Kelly Field, Texas—1,400 miles in approximately 13 hours. They flew on schedule in perfect formation in poor weather, without a single mechanical breakdown in any motor.

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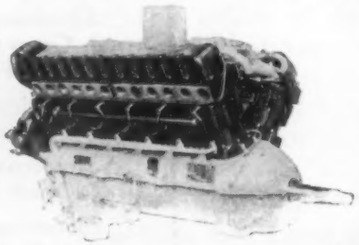
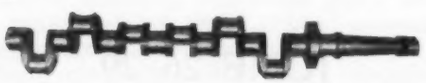


435 H. P. Curtiss D-12 Airplane Engine



Thisforged Nickel Alloy Steel crankshaft, used in Curtiss D-12 engine, weighs 61 lbs. and transmits 435 H.P., slightly over 7 H. P. per lb. of weight.

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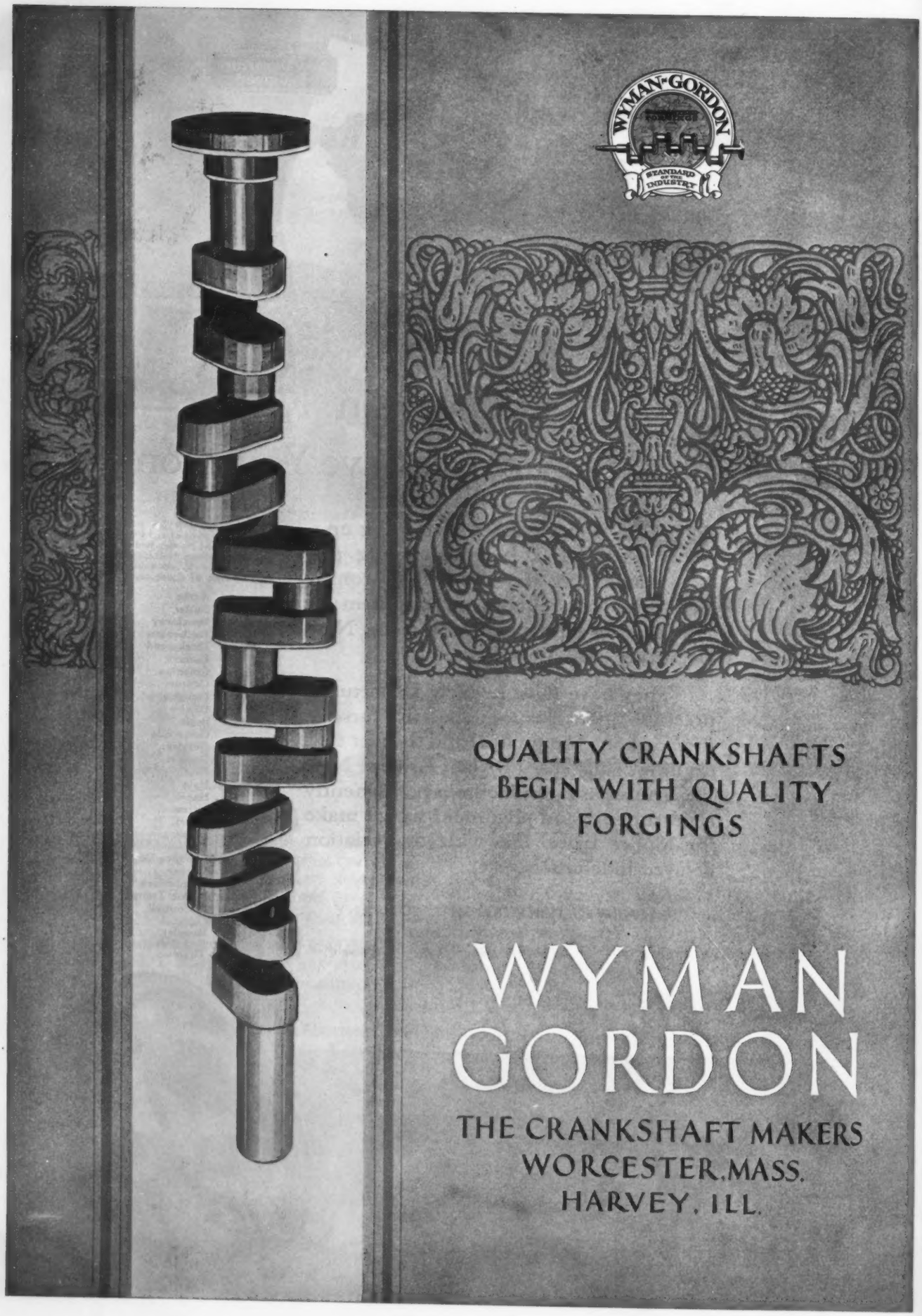
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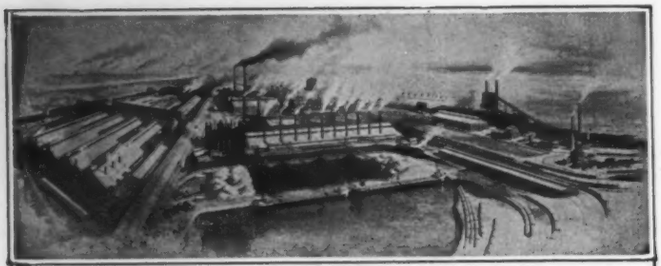

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Notes and Reviews

Continued

mere listing of the items is formidable; organizations, their objects and their officers; Government departments dealing with aviation; airways; technical and periodical literature; aircraft production and export; flying clubs; races and competitions; pilots and flying operations.

This, the tenth successive Aircraft Yearbook, takes its place as an important member of a worthy series.

The Aeroplane Speaks. By H. Barber, Published by Robert M. McBride & Co., New York City. 148 pp.; 135 illustrations. [A-3]

"It seems very pretty," said Alice in Wonderland after she had read the poem on the Jobberwock, "but it is rather hard to understand," and thus expressed, for all time, the frame of mind of lay readers of the usual type of book on technical subjects.

To satisfy the curiosity of the many thousands of present-day Alices on aviation, The Aeroplane Speaks has been written. It sets forth simply and clearly the principles of mechanical flight, and the rôles played by the different parts of the airplane in bringing them to the stage of practice. The author marshals to his assistance humor, imagination and fine writing; he is entertaining and becomes at times the spokesman for the beauty of experience and outlook to be gained from three-dimensional travel.

In the first part of the book, the elementary principles are personified and show, in conversation and blackboard illustration, the synthesis of the airplane. The second part deals a little more formally but no less instructively with the airplane structure necessary for flight, with stability and control, the rigging, propellers, and the maintenance and inspection of aircraft.

CHASSIS PARTS

Researches on Springs; the Endurance of Spring-Steel Plates under Repetition of Reversed Bending Stress. By G. A. Hankins. Engineering Research Special Report No. 5. Published by Department of Scientific and Industrial Research, London, England. 26 pp.; 5 illustrations. [C-1]

Although in 1 year alone during the war more than 500 tons of spring-steel material for motor-vehicle repairs was supplied to the British Expeditionary Force in France, in addition to thousands of complete springs and bearings for the frame, the supply of replacements and repair materials was unequal to the demands. To bolster the weak link thus revealed in the chain of army motor transport, the Department of Scientific and Industrial Research, with the cooperation of the industry, has conducted investigations into the materials and the design of laminated springs. The present report is the first of a series covering this research.

For the fatigue testing described, an experimental method was devised that represents more exactly than does the conventional procedure the conditions of use. About 20 commercial steels, heat-treated by a private firm, were tested. Additional specimens heat-treated by the National Physical Laboratory were then investigated.

A third section examines the value of the testing machine when considered as a reversed-plane bending-fatigue machine, and the results obtained with it are compared with those given by the rotating cantilever or Wohler bending-fatigue test. Finally, the investigators showed by experiment the effect of surface defects and clamping stresses in reducing the resistance of spring-steel plates to bending fatigue.

How Rotational Kinetic Energy Affects Acceleration. By G. B. Upton. Published in *Automotive Industries*, April 21, 1928, p. 624. [C-1]

Hill-climbing performance may not be translated, without

(*Continued on next left-hand page*)

High Compression

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GREATER piston travel, higher compression and higher speeds demand better piston rings.

Rings must be absolutely and positively accurate, of proper tension, quick seating, and made of highest grade castings to insure an efficient, long life.

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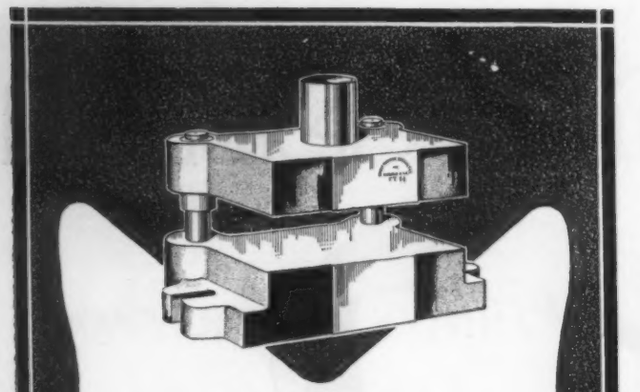

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Notes and Reviews

Continued

further data, directly into corresponding acceleration performance. Whereas the only type of kinetic energy affecting the former is the translational energy, depending on the loaded weight of the car and its forward speed, in the latter the rotational kinetic energies in the road wheels, the engine and the clutch must also be considered.

Methods of calculating the rotational kinetic energies that affect car performance are set forth, and comments are made as to the relative accelerating abilities of different types of car as revealed by such calculations. For instance, the advantage of a larger number of cylinders for acceleration performance, even if hill-climbing ability remains unchanged, is demonstrated. A table shows concretely why the European type of car with the high-speed small engine has not the acceleration of the American cars having relatively low-speed large engines, although the European cars are as good hill-climbers as ours when the gears are shifted to give the engine sufficient advantage.

Physical Bases of Tire Cord Properties. By H. P. Gurney and E. H. Davis, Published in *India Rubber World*, March 1, p. 53, and April 1, 1928, p. 63. [C-1]

While the manufacture of tire cord has improved considerably since its adoption a few years ago, the superiority of the present day tire is largely due to improved tire building, the authors contend. Contributing to the study of the tire carcass, which will, it is thought, become increasingly intensive, this article assembles a large number of data on tire cord properties. First the characteristics of cotton fiber are enumerated, then those contributed by the manner of construction, after which cord properties are finally reviewed.

Le Problème de l'Indépendance des Roues d'Arrière. By D. Sensaud de Lavaud. Published in *La Technique Moderne*, April 1, 1928, p. 260. [C-1]

Acting evidently on the theory that if one teaspoonful of medicine is a palliative, a cupful is a sure cure, some designers have extended the use of independent wheel suspension from its legitimate field, the front end, to the rear end. To make good his protest against this practice, the author outlines the advantages of independent springing for the steering-wheels, as covered by him more fully in previous publications. He then analyzes mathematically the effects of applying the system to the driving wheels, and comes to the conclusion that it affects deleteriously both riding-qualities and tire wear. Contrasted with this is the conventional axle.

Special features incorporated with the author's design of independent front-wheel suspension, such as rubber mounting of the wheels, wide tread, and a balancer, are explained. Recommendations for achieving a certain degree of independence for the rear wheels close the article.

ENGINES

The Performance of Several Combustion Chambers Designed for Aircraft Oil-Engines. By William F. Joachim and Carlton Kemper. National Advisory Committee for Aeronautics Report No. 282. Published by National Advisory Committee for Aeronautics, City of Washington. 12 pp.; 13 illustrations. [E-1]

Several investigations have been made on single-cylinder test-engines to determine the performance characteristics of four types of combustion chambers designed for aircraft oil-engines. Two of the combustion chambers studied were bulb-type precombustion chambers; the other two were integral combustion chambers, one being dome-shaped and the other pent-roof-shaped.

The results obtained indicate that aircraft-type oil-engines

(*Continued on next left-hand page*)

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Notes and Reviews
Continued

with suitably designed combustion chambers and fuel-injection systems may be operated at speeds of about 1800 r.p.m. without encountering excessive explosion pressures. At a speed of 1600 r.p.m., and with a fuel quantity giving 15 per cent excess air in the cylinder, a maximum indicated mean effective pressure of 119 lb. per sq. in. was obtained with a fuel consumption of 0.43 lb. per i.hp-hr. A minimum fuel consumption of 0.26 lb. per i.hp-hr. at an i.m.e.p. of 52 lb. per sq. in. and 1600 r.p.m. was obtained with a cylinder-head having a bulb-type precombustion chamber.

The conclusion drawn is that an increase in the specific power-output of the high-speed aircraft oil-engine depends upon higher mean effective pressures and an improvement in mechanical efficiency. The best performance for the tests reported was obtained with a bulb-type combustion-chamber designed to give a high degree of turbulence within the bulb and cylinder.

Geeignete Legierungen für die Herstellung von Aluminiumguss-Kolbenrohlingen. By H. Reininger. Published in *Der Motorwagen*, April 10, 1928, p. 217. [E-5]

That extensive research on and utilization of aluminum alloys for piston material have been going on in Germany in recent years is indicated in this article, which enumerates the qualities that aluminum alloys must have to meet the conditions both of engine usage and production, and indicates how, in the opinion of the author, these requirements may best be met.

Tables are given comparing the characteristics of cast iron and aluminum alloys as piston material and listing the aluminum alloys generally used in Germany, together with their manufacturers, their composition and remarks on their suitability for internal-combustion-engine use. Brief comments are also made on the influence of various alloying metals on the properties of aluminum alloys.

HIGHWAYS

The Problem of Automobile Exhaust Gas in Streets and Repair Shops of Large Cities. By J. J. Bloomfield and H. S. Isbell. Published in *Public Health Reports*, March 30, 1928, p. 750. [F-1]

Much discussion has been had on the possible menace to public health from the carbon-monoxide content of automobile exhaust-gas in city streets; but few actual data on the extent of the hazard have reached publication. This deficiency assures a welcome to the present report of conditions in 14 large cities in which 250 samples of air were obtained and analyzed.

The observations were made in a way to indicate the maximum hazard, and, in the words of the authors, "The figures for street air, when viewed in the light of present-day standards of exposure to carbon monoxide, do not reveal the existence of a health hazard from this source in our city streets." Even less of the poisonous gas is present in the interior of exhaust-treated motorcoaches than in the streets.

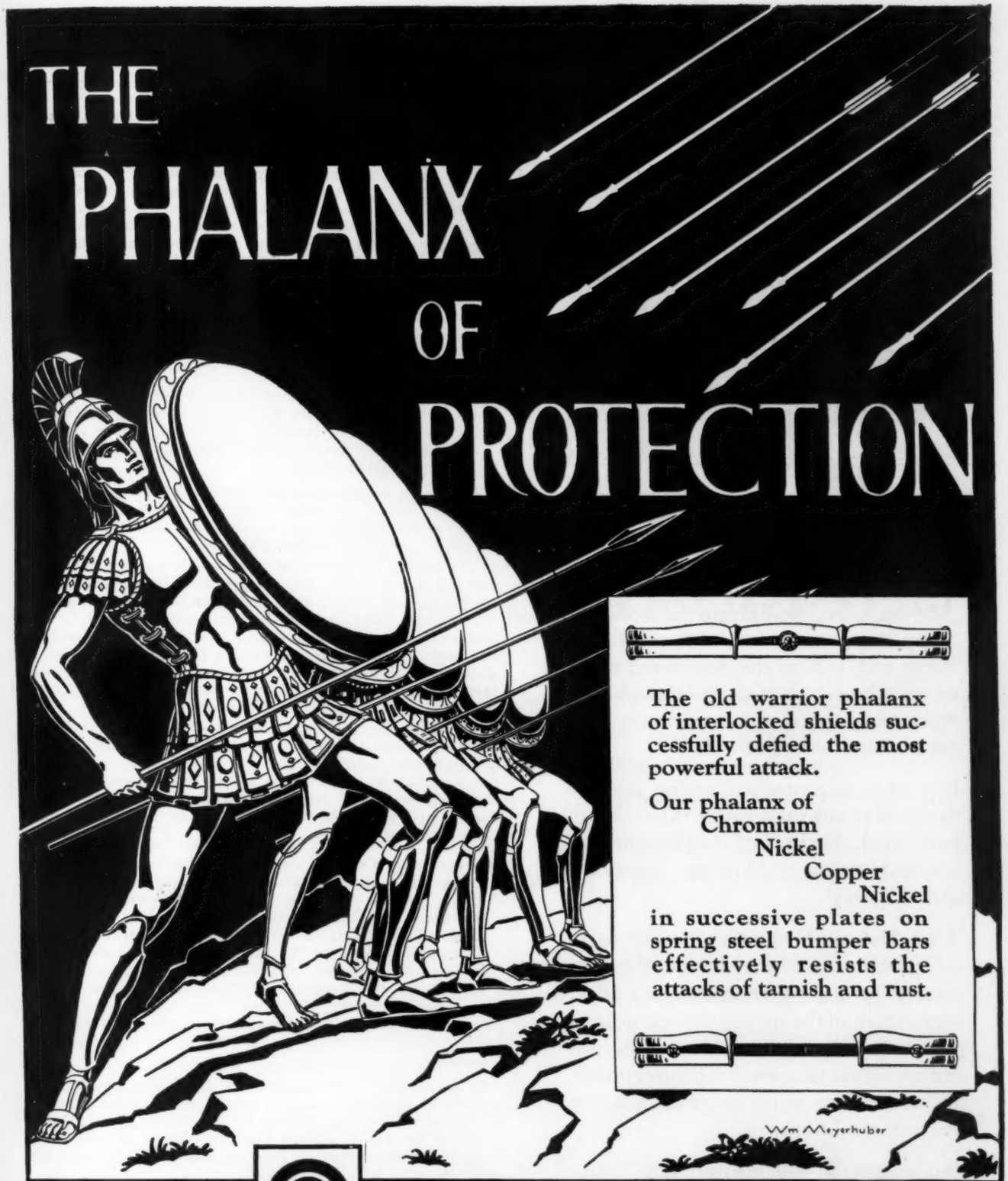
An entirely different conclusion is reached as to garages. It is based on 102 tests made in 27 repair shops, the results of which are said to show a dangerous condition that demands the serious consideration of those concerned. The remedy suggested is that, when an engine must run for longer than 30 sec., the gases be exhausted into the outside air by a direct air-tight outlet of ample caliber.

MATERIAL

Graphical Methods in Lacquer Technology. By H. E. Hofmann and E. W. Reid. Published in *Industrial and Engineering Chemistry*, April 1928, p. 431. [G-1]

Entering the commercial arena at the same time that technical investigation and control were coming to the fore, the lacquer industry has from the beginning worn a scientific complexion. Its problems lend themselves to mathematical or graphical treatment, and the authors' purposes

(*Continued on next left-hand page*)



C G *chromium plated* BUMPERS

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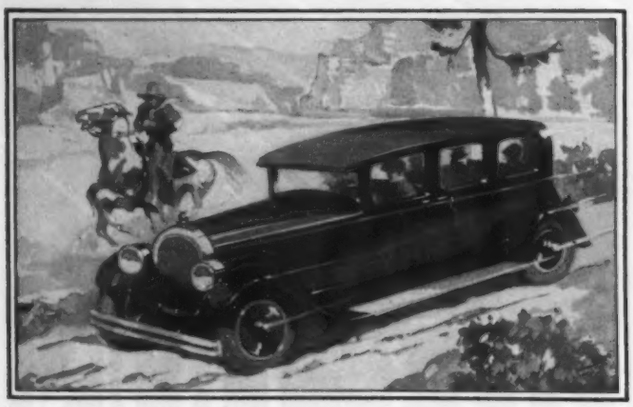
MONROE HYDRAULIC SHOCK ELIMINATORS



Prevent Rough Riding!

UNCONTROLLED automobile springs are, of course, only partially efficient. They compress when the car hits a bump and cushion the downward throw of the body. But they immediately react, with almost the same force, causing a violent spring rebound.

It is this uncontrolled spring reaction that makes any car a rough rider—translates road shocks into unpleasant and uncomfortable galloping, bouncing and sidesway!

With Monroe Hydraulics, "cushions of oil" gently resist the reaction of the compressed springs—permit always a slow, even return of the springs to their normal position. A combination metering pin and springless escape valve insures unfailing oil pressure relief under all road or weather conditions.

Our engineers will gladly equip a test car—show you how Monroe Hydraulics *permanently* control spring reaction and add new riding qualities to the car you manufacture.

MONROE AUTO EQUIPMENT COMPANY
1404 East First Street, Monroe, Michigan

Notes and Reviews
Continued

in this paper are to illustrate some of the common graphical methods applicable in lacquer technology, and to point out their peculiarities and methods of analyzing them.

The use of rectangular coordinates in representing boiling-point, evaporation and tensile-strength curves, and dilution ratios is exemplified. Such problems as the solubility of nitrocellulose and resins, the composition of a solvent mixture at various stages of evaporation, the behavior of a certain combination of solid ingredients in solvents of varying composition, the variation of viscosity with solvent composition, and costs are shown to be dealt with best by the triangular-coordinate system. The authors point out wherein the statistical method may be used in lacquer technology and block out the province of the nomographic or alignment chart.

Effect of the Testing Method on the Determination of Corrosion Resistances. By H. S. Rawdon and E. C. Groesbeck. Bureau of Standards Technologic Paper No. 367. Published by Bureau of Standards, City of Washington. 37 pp.; 25 illustrations. **[G-1]**

To obtain comparative data on the effects produced by different testing methods, tests were made on a copper-nickel series consisting of copper, nickel, and three copper-nickel alloys, all of commercial grade.

The testing methods tried were simple immersion in non-aerated and aerated solutions; repeated immersion, both continuous and intermittent; spray; and an accelerated electrolytic test. The corrosive solutions employed, all of normal strength, were hydrochloric and acetic acids, sodium and ammonium hydroxides, sodium chloride and potassium dichromate used as an oxidizing agent. A few supplementary simple immersion tests were made in which nitrogen gas replaced air for agitating the solution.

The corrosion rate and the order of relative corrodibility of the five materials were found to vary considerably for different test methods. The results clearly indicated that the essential features of the service to be met should be incorporated in any corrosion test designed to give information concerning the suitability of a metal for some particular type of service.

Researches on Cellulose Acetate and Its Solution: Part 1, Composition of Cellulose-Acetate Lacquer for Aeroplane Dope; Part 2, Stability of Cellulose Acetate; Part 3, Stabilizer for Cellulose-Acetate; Part 4, On the Acetylation of Cellulose; Part 5, Relation of Temperature and Time of Ripening to the Viscosity of Cellulose-Acetate. By Katumoto Atsuki, Ryo Shinoda and Yoshio Tanaka. Reports of the Aeronautical Research Institute, Tokyo Imperial University, No. 32-36. Published by the Tokyo Imperial University, Tokyo, Japan. 19 pp., 4 illustrations; 17 pp.; 9 pp.; 8 pp., 1 illustration; 8 pp., 2 illustrations. **[G-1]**

In the research here reported the optimum composition of the mixed solvent for cellulose acetate in the preparation of an airplane dope was studied by determining the solvent power of the mixed solvent, the viscosity of the cellulose-acetate solution in the mixed solvent, and the tensile strength and elongation of the film produced.

Stability of the cellulose acetate was found to be affected most decidedly by the sulphuric acid present. The method proposed by the authors for testing for stability is described.

Calcium naphthenate was decided upon as the most effective stabilizer for cellulose acetate as well as for cellulose nitrate, in the third section of the research project. A fourth division comprised experiments to determine the reactions involved in acetylation.

Experiment and theoretical calculation, in the last section of the research, developed the expression $T = ae^{kz}$ for

(*Continued on next left-hand page*)

Announcing

NEW MODEL "U" STROMBERG CARBURETOR

This latest development of the Stromberg Laboratories has many new and distinctive features which approach the exacting requirements of the modern motorist more closely than any carburetor yet manufactured.

Designed to provide maximum power and speed, as well as extraordinary smooth operation when engine turns over slowly.

The ingenious pump attachment gives that quick, snappy acceleration that is the delight of the modern motorist.

Excellent performance without sacrificing economy in gasoline consumption.

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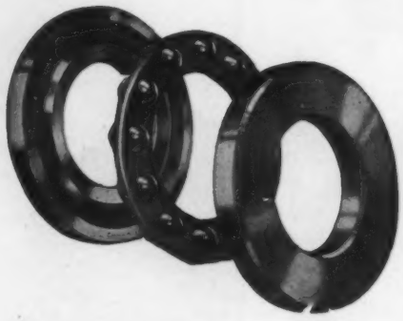

Relentless competition between automobile manufacturers has greatly increased the standard of motor car design and value. On the other hand, it has decreased prices. Naturally, whenever prices must be lowered, the purchasing department of any manufacturer must lean more and more towards economy.

There are certain units of any automobile which can be cut down in quantity or quality to help reduce costs. These units, more of the accessory or luxury type, do not greatly determine the performance of the car. But—down in the heart of the chassis, the clutch, the steering column, the steering knuckle—wherever fine performance depends upon the almost total elimination of friction—quality must prevail and every unit, every thrust bearing, be selected for 100% efficiency.

Thrust Bearings—unseen because they are forever at work in the vital parts of the car—unfamiliar to the car owner because they are seldom brought to his attention—*must* be dependable. And—if they are Aetna made and Aetna guaranteed—they are made to the regular Aetna standard of "precision beyond specifications."

Our Engineering Department stands ready at any time to consult with any manufacturer in the design of special thrust ball bearings, or to quote on Aetna Bearings as standard equipment. Let us send you the latest Aetna Engineers' Catalog with complete specifications.

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NORMAL STEEL
Required for Aetna Bearings. Note the even grain structure.
ABNORMAL STEEL
Not up to Aetna standards. Note the uneven grain structure.

Notes and Reviews

Continued

a given viscosity, in which T is the temperature, z is the time of ripening and a and k are constants.

Creep in Five Steels at Different Temperatures. By H. J. French, H. C. Cross and A. A. Peterson. Bureau of Standards Technologic Paper No. 362. Published by Bureau of Standards, City of Washington. 30 pp.; 25 illustrations. [G-1]

This report describes so-called creep tests in which the elongation of metal specimens under a fixed load is observed with relation to time. Tests were made on a low-carbon structural steel, a high-chromium steel, a chromium-molybdenum structural steel, high-speed steel, and a high-chromium-high-nickel austenitic steel; and the results were correlated with short-time tension tests at corresponding temperatures within the range 70 to 1350 deg. fahr.

So-called creep charts are given in which the relations are shown between stress, temperature, elongation, and time for each of the steels. These charts enable the approximate determination of the stress permitting life of different durations with different total elongations. The application of these charts is discussed in some detail.

The high temperatures and pressures associated with recent developments in powerplant equipment, oil-cracking processes, and the chemical industries have shown the need for such additional information on the behavior of metals at high temperatures.

Annales de l'Office National des Combustibles Liquides. Published by the Ministère du Commerce at de l'Industrie, Paris, France. 158 pp. [G-3]

This report of the National Department of Liquid Fuels of France contains three items on detonation. The first recounts experiments made to determine the effect of knock suppressors on ignition temperatures. The conclusion reached is that the small quantities of anti-detonants needed to raise the permissible compression ratio have no effect, although larger quantities than are customarily used do, in some cases, raise the ignition temperature.

In the second item, the theory is advanced that anti-detonants are effective because they prevent the formation of peroxides and, consequently, the creation of an explosion wave. From experiments recounted in the third item, the conclusion is drawn that the speed of the explosion wave is independent of the presence of anti-detonating substances.

Other items contained in the report, which is one of six issued annually, are discussions of the low-temperature carbonization of coal and the production of alcohol for fuel, statistics of liquid-fuel imports and exports, and official records of the department.

Copper and Copper Alloys. By W. H. Bassett, Published in *Mining and Metallurgy*, April, 1928, p. 170. [G-3]

An increase in its consumption from 70,000,000 lb. in 1921 to 250,000,000 lb. in 1926 is cogent proof of the interest of the automotive industry in copper and copper alloys. The rise results, not solely from the greater number of automobiles manufactured, but also from the larger quantity of the metal used per vehicle. On an average, the smaller and cheaper cars take 30, and the largest and more expensive cars 700 lb. of copper apiece, according to the estimate made in this article.

After mentioning the properties of copper as revealed in and affected by commercial production, the author turns to the alloys. He discusses particularly the copper-silicon alloys, specifically Everdur and one recently patented by Corson. These, he says, open a new field for copper in engineering, since they are cheaply and effectively hardened. The functions performed by cadmium and nickel as alloying elements are outlined, and the chief users of copper and copper alloys, together with their requirements, are listed.

(*Continued on next left-hand page*)

"SAVAGE COMPETITION...."

.... The Wall Street Journal

The well-informed financial daily prophesies that this "savage" competition in the automobile field is becoming intensified.

The bus and truck fields—where the buying is done by experts—felt the savage competition some time ago. They couldn't afford to slip up on a single detail.

They installed the H-W Filtrator as standard equipment, after proving that it was the only perfected, permanent scientific solution of oil filtration problems.

H-W Filtrator pioneered this "in-line" filtration, placing the non-disintegrating filtrator element between the oil pump and the bearings, affording initial and continuous protection to the finely finished surfaces of the crankshaft and bearings.

Are you going into this "savage" battle to enthuse your prospects with "new standards of performance; new luxury of appointments; new ultra modish lines," only to finish with the same old warning "remember to change your oil every 500 miles"?

Or are you to say as the truck and bus manufacturers say: "We offer you perfect filtration, save you 75% of your oil costs, and insure complete protection of bearings which were tested, at the cost of millions, to the thousandth part of an inch in our experimental laboratories"?

If you are to make the latter claim, you must use the H-W Filtrator. There is no substitute.

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Hall-Winslow Patents

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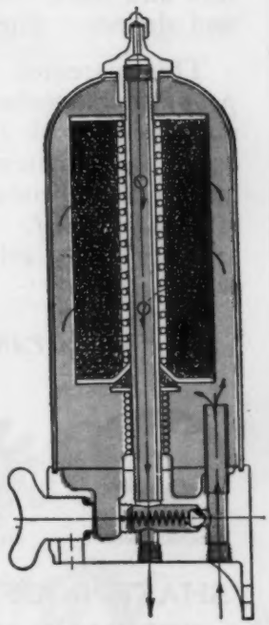
Truck and Bus Operators

You can now secure Filtrator-equipped engines on the following: Hall-Scott, Hercules, Continental, Waukesha, Buda and Wisconsin



WATSON OIL-RITE SYSTEM

Automotive engineers will be vitally interested in the Watson Oil-Rite System, a new and better lubrication system which easily doubles engine life.

The essential features of the Watson Oil-Rite System are the following:

Keeps lubricant permanently free of abrasives, fuel, acid, water, sludge. Applies oil copiously at the initial starting period. Regulates oil supply while running. Heats oil promptly on starting of engine. Keeps oil cooled under top temperature conditions.

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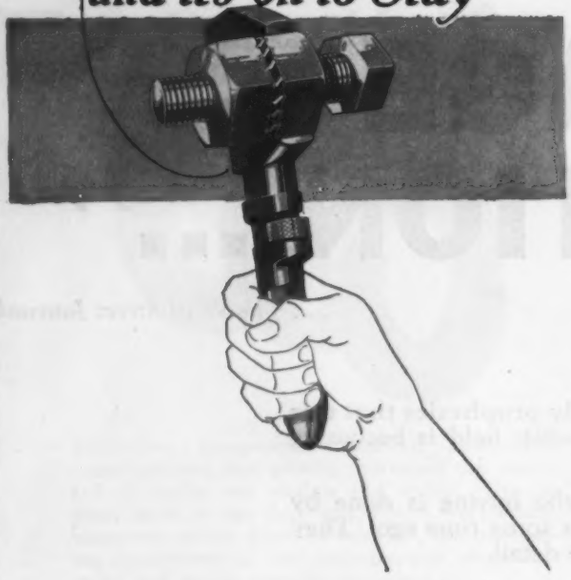
H-W FILTRATOR

A Turn of the Wrench and it's on to Stay



Here's a lock washer rightly named. It is *shake proof* in fact. Here's why:

Ten or more *twisted* teeth are set at equal intervals around the circumference of the washer. One turn of the wrench and those teeth bite into both nut and work, forming a *positive* lock. Many more turns and twists of *vibration* and those twisted teeth bite deeper and deeper. Simple, isn't it?

This patented and genuinely *shake proof* lock washer is used upon large and small work in hundreds of different lines—making better connections and cutting production costs because it is *tangle proof*. Write today for free samples. Just tell us kind and size of work.

"NOT A TANGLE IN A TON"

Type 12 Internal Teeth — Type 15 Countersunk — Type 11 External Teeth

SHAKEPROOF LOCK WASHER COMPANY INCORPORATED

(Division of Illinois Tool Works)

2507 North Keeler Avenue, Chicago, Illinois

Notes and Reviews

Continued

Metal Statistics, 1928. Published by American Metal Market, New York City. 552 pp. [G-3]

This handy little volume contains a large number of tables incorporating some general information but presenting for the most part data on the production, consumption and prices of metals. The prices are wholesale and are based on the daily quotations appearing in *American Metal Market*. The American Iron and Steel Institute furnished the iron and steel production statistics, and the Bureau of Mines and the American Bureau of Metal Statistics those on other metals.

Conditions not only in the current but also in previous years are shown in the tables. The materials for which information is given include iron and steel, in the raw, semi-finished and finished states; and fuels, aluminum, antimony, copper, brass, bronze, lead, nickel, platinum, silver, tin, and zinc.

Methods of Dealing with Paraffin Troubles Encountered in Producing Crude Oil. By C. E. Reistle, Jr. Bureau of Mines Technical Paper No. 414. Published by Bureau of Mines, City of Washington. 39 pp.; 16 illustrations. [G-5]

The temperature of the crude oil, which may be lowered by heat radiation or the lifting action of the gas; the loss of volatile constituents, and the presence of suspended inorganic material, are listed as the three main conditions affecting paraffin accumulation during crude-oil production.

In seeking preventives for the formation of paraffin in production, the author analyzes the problem for each type of well. For flowing wells, decreasing the gas-to-oil ratio and the size of the oil string are recommended. Wells flowed by compressed air or gas should be operated with an oil string small enough to render possible continuous or virtually continuous production. The provision of gas anchors and back pressure on the tubing are precautions suggested for pumping wells during the transition period. The author also discusses preventives of paraffin accumulation in the sand, flow-lines and tanks.

When the accumulation of paraffin cannot be prevented, investigation must be made into methods for its removal. Descriptions are given of standard tools, electric hoists, pulling rods, and paraffin hooks, knives and augers. Suggestions are made as to the use of solvents, electric heaters, steam, and chemicals.

Examples from practice illustrate the points made in this paper.

Electric-Furnace Cast Iron. By C. E. Williams and C. E. Sims. Bureau of Mines Technical Paper 418. Published by Bureau of Mines, City of Washington. 48 pp.; 10 illustrations. [G-5]

This paper represents work conducted at the Northwest Experiment Station of the Bureau of Mines, at Seattle, Wash., in cooperation with the College of Mines, University of Washington. The work was started in the laboratory in 1920 and was completed in 1925, after a year's successful operation of a jobbing foundry in Vancouver making miscellaneous gray-iron casting from steel scrap.

The conclusions arrived at are that electric-furnace cast iron is stronger, tougher, and more dense than cupola iron, and a higher recovery of metal in casting can be obtained as a result of the higher pouring temperature. Cast-iron scrap of high-sulphur content can be converted into high-grade cast iron, low in sulphur, either by melting directly in the electric furnace or by refining molten metal from the cupola. Large additions of steel scrap may be used if desired, or steel scrap can be used entirely and synthetic cast iron made.

(*Continued on next left-hand page*)

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—modern improvements introduced in Original-Bosch Super-Energy Magneto, meet every modern need.

HERE at last—in the Original-Bosch Super-Energy Magneto is a magneto designed for 1928 performance. Do you require:

—a wide range of operating speeds? The Original-Bosch Super-Energy Magneto gives absolute dependability at the highest speeds. It throttles down to low speeds without shifting gears, yet picks up again smoothly.

—super-energy? This magneto introduces a new principle—the principle of Super-Energy. Notice the increase in engine power, the new agility on hills, the added dependability in performance regardless of loads or roads.

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—freedom from attention and repairs? Its waterproof and dustproof construction, a special aluminum alloy frame instead of a die casting, a high speed interrupter,—these are a few reasons why this magneto protects automotive engines from ignition failures and costly breakdowns. Why, you don't even have to oil this magneto

If you want 1928 magneto efficiency, write for full information about the Original-Bosch Super-Energy Magneto.

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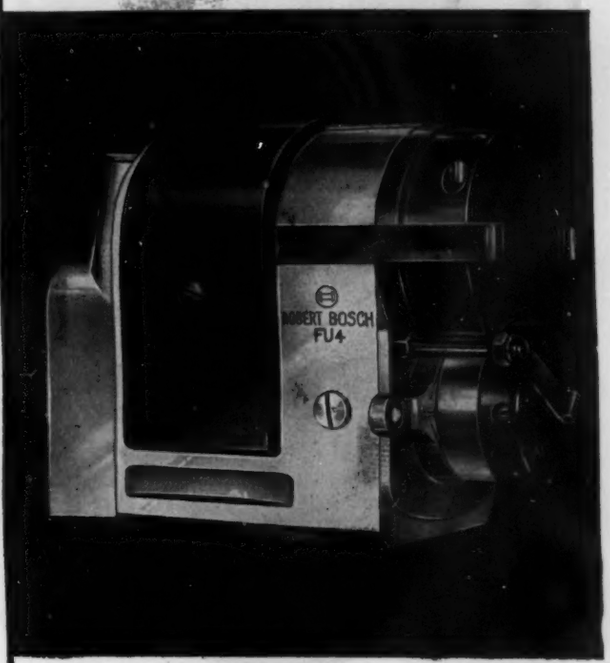

The full name Robert Bosch and the Robert Bosch trademark appear on all Original-Bosch products—your guaranty of Original-Bosch quality as known the world over since 1887.

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Hundreds of thousands of instruments in actual service testify to the efficiency and serviceability of these units.

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Notes and Reviews

Continued

Some of the advantages of the production of synthetic cast iron are that plants can be kept in operation during periods of idleness; that the composition of the product can be controlled, and that scrap is utilized. Estimated costs per ton for produced metal in the ladle are: gray iron from steel scrap, acid, $26.65, basic, $26.40; from iron scrap, acid, $25.95, basic, $26.70; white iron from steel scrap, acid, $22.05, basic, $22.65.

MISCELLANEOUS

Matter, Electricity, Energy. By Walter Gerlach; translated by Francis J. Fuchs. Published by D. Van Nostrand Co., Inc., New York City. 427 pp.; 119 illustrations. [H-1]

The extremely friendly reception accorded to the German editions of this book, indicating its appeal alike to chemist, practical physicist, technologist and engineer, prompted the translator to make the volume available to all English-speaking persons who are interested in the application of physical concepts to scientific endeavor but are unable to peruse the book in the original.

The author, in a clear survey of recent developments, has presented the principles of modern atomistics and experimental results of atomic investigation in a way to serve, not so much the trained physicist, as the scientifically inclined philosopher interested in a better knowledge of natural science. Therefore, a comprehensive discussion of the individual phases of the subject matter has not been attempted but, rather, the essentials of several topics of paramount importance have been presented. The treatment covers somewhat inspirationally the significant phases of those subjects that are particularly susceptible of additional development and which are expected to stimulate further research on the part of the reader while giving him a clearer understanding of general atomistics. This result is acceptably attained through a series of closely related and interdependent treatises, each constituting a complete unit within itself.

The author, for the most part, presupposes no special technical knowledge on the part of the reader, and in the translation the text has been stripped of highly technical terms insofar as is advisable in the treatment of such an involved subject. Mathematical formulation has been dispensed with almost entirely.

Probability and Its Engineering Uses. By Thornton C. Fry. Published by D. Van Nostrand Co., Inc., New York City. 423 pp.; 49 illustrations. [H-1]

The author faces squarely the logical difficulties with which the foundations of the theory of probability are fraught, and the clear-cut, straightforward discussion of these difficulties will be welcomed by readers who like their thinking "straight."

A clear exposition of the fundamental concepts of the probability theory is not easy; in books on this subject clarity frequently is sacrificed for rigor, or rigor for clarity. Dr. Fry has been very successful in achieving both clarity and rigor compatible with the scope of the book.

The author assumes that, except for some knowledge of calculus, the reader has forgotten his mathematics—a wise assumption—and builds the mathematical theory from the ground. Starting with the two "laws of composition," the formulas for permutations and combinations are derived and illustrated with examples. Gamma functions, the binomial theory, and the illuminating problem of the cylinder lock, are discussed.

Chapter III deals with probabilities proper, and includes a number of practical examples. In Chapter IV much attention is given to Bernoulli's theorem, which is the link between *a priori* or theoretical probability, on the one hand,

(*Concluded on next left-hand page*)

TEXTOLITE

When Textolite replacement gears are desired, complete details and the name of the nearest distributor can be obtained from:

John C. Hoof & Company
162 North Franklin St., Chicago, Ill.

Every timing gear on which Textolite appears is, in material, design, manufacture, and test, as nearly perfect as non-metallic gears can be made. There has never been nor can there ever be any compromise on the quality of Textolite.

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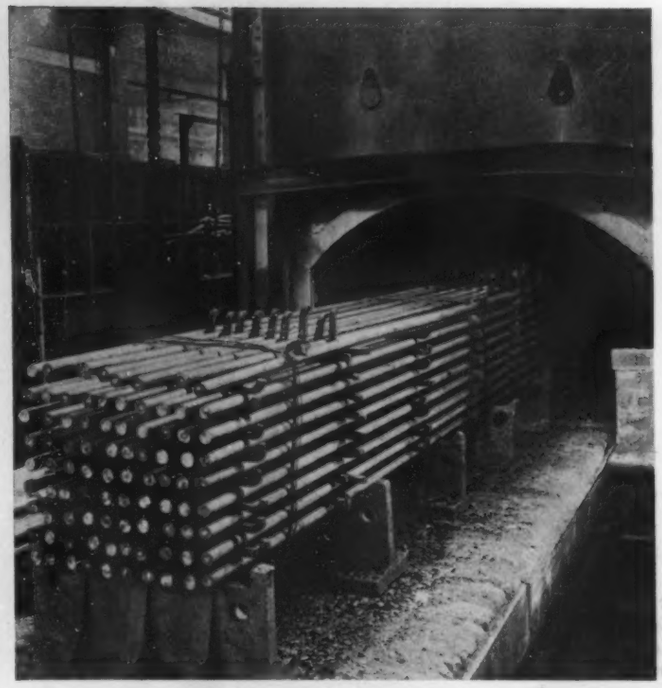

Removing alloy steel bars from annealing furnace in Bethlehem Alloy Steel Plant, Bethlehem, Pa.

Sinews of Motor Transportation

CLOSELY interwoven in the growth of the automotive industry has been the development of alloy steels to supply the strength and toughness so necessary in the vital parts of motor vehicles. As the requirements of the industry became more and more exacting new alloy steels were produced to meet them. As metallurgical research pointed out ways of making better steel, automotive engineers quickly made use of the improved product.

The continuous research, experiment, and testing carried on by Bethlehem is a guarantee that in the future, as in the past—and present — automotive manufacturers can look to Bethlehem as a source of supply for exceptionally satisfactory alloy steels.

Bethlehem metallurgists will gladly give you the benefit of their experience.

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BETHLEHEM ALLOY STEELS

Notes and Reviews
Concluded

and practical or experimental probability, on the other hand. A clear derivation of Sterling's theorem is given. Chapter V considers several interesting problems and paradoxes and Bayes' theorem. Chapter VI introduces continuous variables into probability considerations, and includes a discussion of Maxwell's equation. Chapters VII and VIII deal with the usual questions: averages, expectations, and distribution functions, including the "normal" law. The rest of the book is devoted, in addition to subject matter conventional in works of this kind, to numerous practical applications and examples, which are particularly interesting from the point of view of the engineer.

The Strength of Flat Plates. By Tandy A. Bryson. **The Strength of Flat Plates.** By Thomas Cheeger. **The Stresses in Flat Plates.** By Harvard H. Gorrie. Rensselaer Polytechnic Institute Engineering and Science Series No. 18. Published by Rensselaer Polytechnic Institute, Troy, N. Y. 60 pp.; 30 illustrations. **[H-5]**

Experimental observations on the important but obscure problem of stresses in flat plates constitute the material of the principal item, presented by H. H. Gorrie. The investigation was the basis for thesis work and was planned to determine (*a*) the variation in the intensity of strains in flat steel plates subjected to uniform load; (*b*) the actual principal axes of strain for various points on the plate; and (*c*) the strain along these axes.

Two plates were tested under loads imposed by hydrostatic pressure. Measurements were made on only one-quarter of each plate, as one-quarter was assumed to be representative of the entire surface.

The first two papers in the pamphlet are given in abstract. That by Tandy A. Bryson developed an equation for designing flat plates; and the work of Thomas Cheeger virtually duplicated Mr. Bryson's work and resulted in substantially the same final equation.

TRACTOR

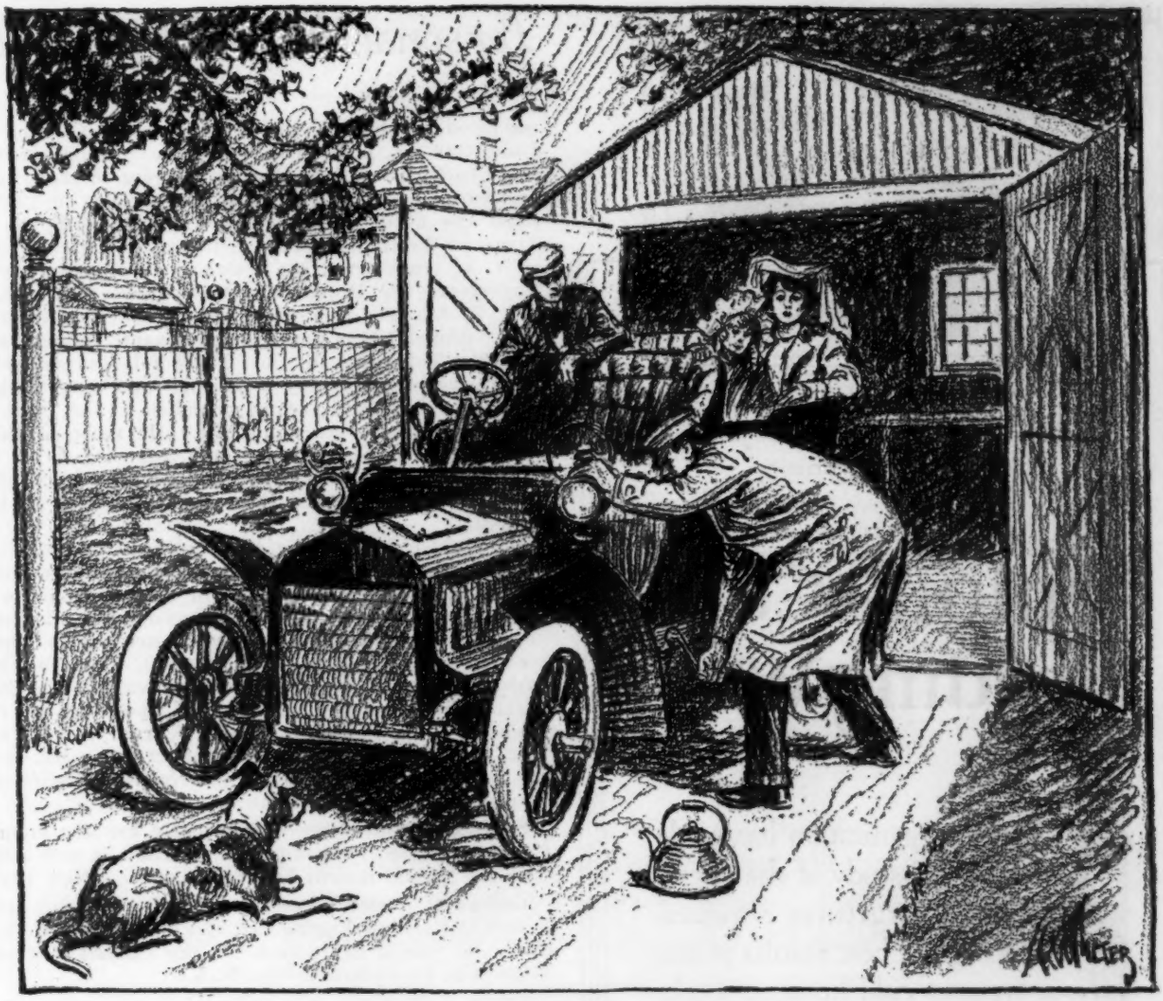
Dynamometer Testing of Ordnance Vehicles at Aberdeen Prooving Ground. By Major A. B. Quinton, Jr., and Capt. John K. Christmas. Ordnance Technical Note No. 9. Published by Engineer Production Plant, City of Washington. 144 pp.; 214 illustrations. **[M-1]**

Dynamometer tests at the Aberdeen Proving Ground are made in the field and in the laboratory. Field tests are made with the recording traction-dynamometer to determine the tractive resistances of trailed loads, the tractive resistances of prime movers, and the drawbar horsepower of prime movers. The efficiency of the transmission can be evaluated in the dynamometer laboratory; hence the track losses and the "track to ground loss" can be determined. The dynamometer laboratory is used for tests of internal-combustion engines and of vehicle transmissions under various conditions.

An investigation is now being made of the best methods of measuring the power input at the clutch simultaneously with the drawbar horsepower determination. With both the power input and output measured, the losses may be determined under actual operating conditions, and the efficiency of the transmission and tracks calculated.

This technical note gives an account of the development of the test equipment and of the present procedure. It contains also a large number of interesting data on the vehicles and parts tested.

The publication here referred to is not available for general circulation, nor is the office of the Chief of Ordnance in a position to answer inquiries on it. However, the Research Department of the Society will be glad to lend to members the copy in its possession or to furnish extracts from it.



In 1904 . . .

BACK IN THE DAYS OF THE SIDE-WINDER AUTOMOBILE, (1904, TO BE EXACT), CERTAIN INTREPID GENTLEMEN DECIDED THAT THE CAR SHOULD BE DIVORCED FROM THE BARN AND LIVERY STABLE. RESULT—THE HOME GARAGE, FORERUNNER OF AN EPIDEMIC OF CORRUGATED-IRON MONSTROSITIES WHICH, AS TIME WENT ON, WERE GRADUALLY IMPROVED UNTIL TODAY THE FAMILY BUS IS STABLED RIGHT IN THE HOUSE ITSELF.

THE home garage created the backyard "gasoline alley"—and "gasoline alley" has kind words to say for Budd-Michelin All-Steel Wheels.

For the good citizens of "gasoline alley" know that Budd-Michelin Wheels bring a greater margin of safety. In skid or crash these wheels of cold-rolled steel withstand terrific blows. No matter what happens, they can't shatter and overturn the car, for steel is shatter-proof.

If a Budd-Michelin Wheel bends, the blow that did it would wreck a wooden wheel. And a bent Budd-Michelin is a small matter. There is the extra wheel to continue the trip and the bent wheel can be straightened out for about $3. Compare that with a towing charge, delay and price of replacing a wrecked wooden wheel!

Budd-Michelins' graceful, curving discs are slow to collect dirt. Like any smooth, even surface, they are easy to wipe or wash. They're smart wheels, too; particularly for the fleet line of today's cars. Because there are five almost instantly demountable wheels to the set, Budd-Michelins take a lot of the profanity out of tire troubles.

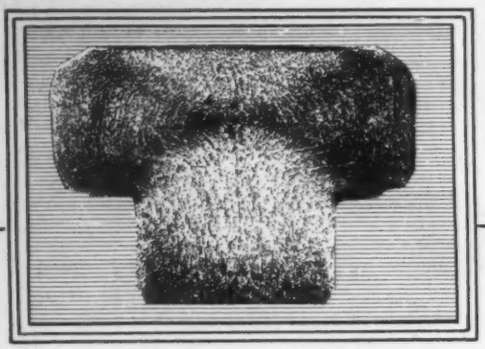
And all of these are good sales points for the men who are offering Budd-Michelin equipped cars.

BUDD

WHEEL COMPANY, DETROIT

Also makers of the Budd Interchangeable Wire Wheel and Budd Dual Wheel

«USE·THE·RIGHT·STEEL·FOR·THE·RIGHT·PURPOSE»



Microscopic view showing grain flow in the cold heading operation.

Union Cold Heading Wire

THIS organization has made a careful study of the microscopic structures required for producing the best results in the various types of cold heading work. Our extensive annealing and cold drawing facilities enable us to supply steels of superior quality for the most difficult cold heading operations.

Union Cold Heading Wire is uniformly free from seams, laps, pipes or other defects. It will not crack under the hard blows of heading machines nor will formed heads come off under severe service conditions.

UNION DRAWN STEEL CO.
Beaver Falls, Pa.

UNION DRAWN STEELS

Personal Notes of the Members
Continued

employed by the Rogers-Haines Machine Co. and the St. Louis Car Co., in St. Louis, and the Westinghouse Co., in New York City. Prompted by a desire to study the engineering field abroad, he sailed for France in 1906 to assume the duties of designing engineer with the Societé Anonyme Westinghouse, of Le Havre and Paris. Four years later, he transferred his activities to Hungary, where he represented the Hungarian Westinghouse Co., only to return to America in 1912 to become chief engineer of the International Motor Co. He subsequently became affiliated with the Tidewater Oil Co. There followed several years' experience in oil-refinery technology and advertising, after which Mr. Stratford became president of the Dixie Chemical Corporation, Petersburg, Va. He resigned this position in 1919 to become petroleum technologist for the Associated Oil Co., located in San Francisco, an affiliation which was to last until the recent formation of his own company.

Ever since joining the Society in 1916, Mr. Stratford has evinced an active interest in Society affairs. He served on the Membership Committee in 1923 and on the Standards Committee, Lubricants Division, for 2 successive years. He is the author of several articles on lubrication that have appeared in THE JOURNAL and the TRANSACTIONS at various times during the years 1915, 1918 and 1921. These include Standardized Specifications for Lubricating Oils, published in the February, 1918, issue of THE JOURNAL and the 1918 TRANSACTIONS. Mr. Stratford has been an active member of the Northern California Section ever since it was organized in 1925.

Swift C. Barnes, who was formerly Eastern manager of the Irving Cloud Publishing Co., Chicago, is now associated with the Mutual Benefit Life Insurance Co., New York City.

George C. Bauer recently accepted a position with the Fairchild Caminez Engine Co., of Farmingdale, N. Y. Formerly he was a draftsman for the Curtiss Aeroplane & Motor Co., Inc., Garden City, N. Y.

Frank J. Brackett, who until lately was manager of the Transportation Survey Department of the Yellow Truck & Coach Mfg. Co., Chicago, is now employed by the General Motors Truck Co., Pontiac, Mich., in a similar capacity.

Kenneth L. Childs has resigned as vice-president and general manager of Selden Truck Corporation, Rochester, N. Y., to form a connection with Darby, Inc., of Boston.

Cedric B. Dicksee, formerly identified with Specialloid, Ltd., of London, England, in the capacity of research engineer, has joined the forces of the Associated Daimler Co., Ltd., of Southall, Middlesex, as designer.

R. C. Dugan now holds the position of supervisor of service in the Milwaukee district for the Oakland Motor Car Co. Previously he was service manager for the Chrysler Corporation of Canada, Ltd., at Windsor, Ontario.

J. B. Franks, Jr., has been appointed a member of the sales personnel of The White Co., at Philadelphia.

Charles Froesch, now project engineer of the Atlantic Aircraft Corporation, at Teterboro Airport, Hasbrouck Heights, N. J., was previously on the engineering staff of the International Motor Co., Long Island City, N. Y.

John P. Gaty, formerly associated with the Premier Laboratory Co., Inc., New York City, as mechanical engineer, has established a similar connection with the Acoustic Products Co., also of New York City.

Paul H. Geyser has resigned as director of sales for the Yellow Truck & Coach Mfg. Co., Chicago, to assume similar duties with the taxicab division of the General Motors Truck Co. located in Pontiac, Mich.

Ross D. Grover has accepted a position as draftsman in the commercial car division of the Reo Motor Car Co., Lansing, Mich. He previously held a like position with the Republic Motor Truck Co., Alma, Mich.

(*Continued on next left-hand page*)

THE PUBLIC IS "BODY-WISE."

Today's automobile models have reached that degree of mechanical perfection where the public is disposed to accept the manufacturer's valuation of performance standards. That is a distinct achievement.

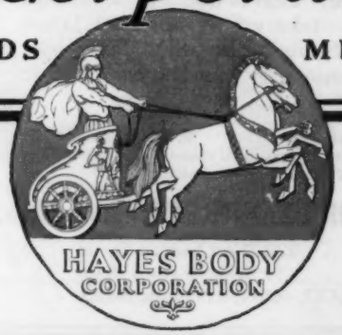
But the body is something else again. Never before did sales depend so much on distinctive bodies—and never was the public so "body-wise."

Hayes master craftsmen have at their command the resources, the facilities, the equipment and the experience to assist in conceiving and producing bodies worthy of any chassis—bodies that will carry a definite appeal to the prospect.

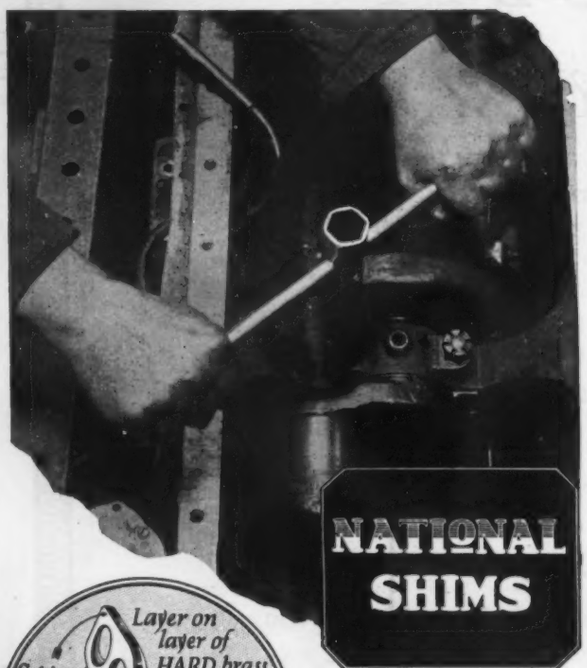
These men are available for conference at any time.

HAYES
Body Corporation

GRAND RAPIDS MICHIGAN



SPEED UP
bearing assembly



—permit wider tolerances, faster work, and fewer rejects

Improvement implies change. Greater efficiency and increased economy are accomplished only thru the introduction of new and improved means and methods. Significant, indeed, therefore, when leaders like *G M C, Twin City, Caterpillar, Dodge, Continental, Wisconsin, Waukesha,* and others change to a new type of shim. NATIONALS are a *double*-action shim, and serve a *double* purpose—they prolong the bearing life of the motor, and expedite bearing assembly and service adjustments. They are made entirely of *hard* brass. They do not compress under bolt pressure. Their thickness is *constant.* Leaves don't stick or curl, simply thumb 'em—take off or put back layers at will, no waste. Submit blueprints for prices. Designs and suggestions by our Engineers upon request.

1. Unit (laminated type) shims 2. Babbit-faced shims
3. Steel shims 4. Steel bronze-faced shims 5. Steel liners
6. Copper liners 7. Brass liners

NATIONAL MOTOR BEARING CO., Inc., Mfrs.

DETROIT . . 222 West Larned Street
CHICAGO . . 30 West Walton Place
SAN FRANCISCO, 460-470 Natoma Street

Personal Notes of the Members
Continued

Paul F. Hackethal is now associated with **W. M. S. Jackson** in consulting engineering work in Detroit. Prior to establishing this connection he was chief engineer of the Duroseal Corporation in Cleveland.

Elbert J. Hall has severed his connection with the American Car & Foundry Motors Co., Detroit, where he was vice-president in charge of engineering and production, to become vice-president and general manager of the Hall Scott Motor Car Co., Berkeley, Cal.

Sidney G. Harris, formerly sales engineer of the Moto-Meter Co., Long Island City, N. Y., has become affiliated with the McGraw Hill Publishing Co. in New York City. He will be on the staff of *Bus Transportation* and the *Electric Railway Journal.*

H. Jay Hayes has resigned as president of the Hayes-Hunt Corporation, Elizabeth, N. J., to accept a similar position with the Victor Body Corporation, a new company recently formed in Lansing, Mich.

Edwin E. Hedene has left the employ of Doble Steam Motors, Inc., San Francisco, to become assistant engineer in the Merco-Nordstrom Valve Co., Oakland, Cal.

J. A. Heinemann, until recently sales manager of the Stafford Sales Co., Chicago, is now connected with the Electric Furniture Corporation of the same city in the capacity of sales engineer.

G. C. Hollandsworth has become factory representative in the Brooklyn and New York territory for the Maccar Truck Co., of Scranton, Pa. His previous connection was with the General Motors Truck Co., New York City.

A. L. Hopkins, formerly with the Prest-O-Lite Storage Battery Corporation, Indianapolis, is now battery engineer for the Delco-Remy Corporation, Muncie, Ind.

J. Harold Hunt has resigned as chief engineer of the Budd Wheel Corporation, Detroit, to accept a like position with the Motor Wheel Corporation, Lansing, Mich. Mr. Hunt will be connected with the steel and wire division of the corporation.

F. L. Jacobus, formerly service manager of the White Motor Co., Newark, N. J., is now maintenance supervisor in the Brooklyn Edison Co., Brooklyn, N. Y.

Harry V. Johansen, until lately sales and experimental engineer in the Detroit office of Brandenburg Bros., has become associated with the Jones Clutch & Gear, Inc., Upper Sandusky, Ohio. He will act as sales and service representative in Detroit.

Charles F. Klinkicht, previously chief electrician of the Jost Storage Battery Co., of Jamaica, Long Island, is now superintendent of gas car maintenance for the Brooklyn Edison Co., Brooklyn, N. Y.

G. C. R. Kuiper has been made assistant chief engineer of the wheel division of the Edward G. Budd Mfg. Co., in Detroit. He was formerly assistant engineer in charge of design for the Jordan Motor Car Co., of Cleveland.

J. B. Mason has been promoted to the position of superintendent of the motor-transport division of the Pure Oil Co., Mexia, Tex., having previously been assistant superintendent of that division.

George L. Michael is now owner and manager of Mike's Cadillac Service, Springfield, Ill. He formerly owned and operated the South Side Garage, located in the same city.

John W. Mills, who until recently was general manager of Fejes Patents Syndicate, Ltd., London, has become associated with the Ascot Motor & Mfg. Co., Ltd., Letchworth, Hertfordshire, England.

C. O. Miniger, president of the Electric Auto-Lite Co., Toledo, and the U. S. L. Battery Corporation, Niagara Falls, N. Y., was recently elected director of the Monroe Auto Equipment Co., located at Monroe, Mich.

(*Concluded on next left-hand page*)

New Colors

that Accentuate New Body Lines—

Motor car lines are changing continually. Bodies are lower; hoods are narrower; radiators are deeper; two-tone effects are present in greater variety.

New body tendencies necessitate new methods of color handling. Let Ditzler color authorities work with you in creating those colors which best accentuate those smart, new body lines. Now that Ditzler Composé Color Panels are available, color selection is made remarkably easy.

Write or telephone for further information today

DITZ-LAC

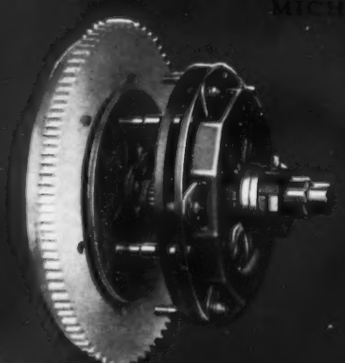
[PYROXYLIN]

DITZLER COLOR COMPANY, DETROIT, MICHIGAN

Stamina

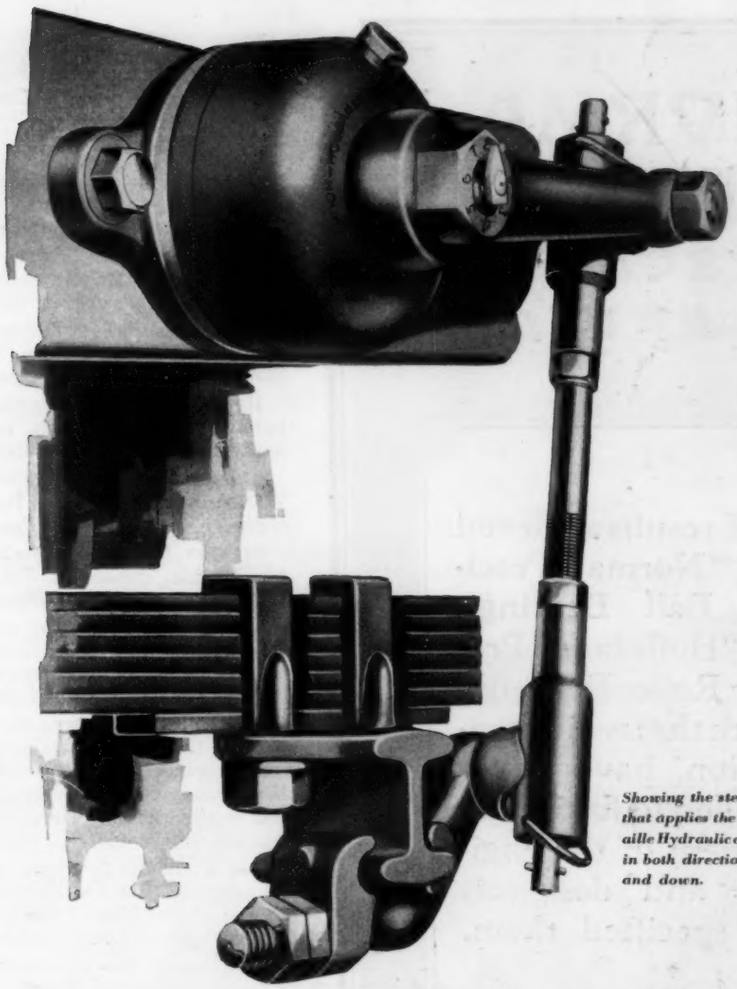
Covering 5,000 miles in less than 4,800 consecutive minutes, a stock model Studebaker Dictator with Long Clutch recently completed another endurance record for stock cars. For nearly 80 hours an average speed of over 63 miles per hour was maintained with the Long Clutch performing satisfactorily all the way.

LONG MANUFACTURING COMPANY
DETROIT MICHIGAN



LONG PRODUCTS
AUTOMOTIVE
RADIATORS
AND CLUTCHES

LONG



Showing the steel arm that applies the Houdaille Hydraulic control in both directions—up and down.

Every Car Dealer can be a HOUDAILLE Dealer

THERE is more than one profit in selling Houdailles. There is a profit on the set of instruments of course, but it doesn't take long to get it noised around town that the cars you sell are the smoothest riding cars that roll on wheels, when you sell Houdailles.

And when it comes to selling a used car, shrewd buyers know that one of the best recommendations it can have is Houdaille equipment. It is a sign that the car was owned by a man who cared and that the chassis has been eased, instead of hammered over the road.

You can only compare a Houdaille with a Houdaille. They are hydraulic and double acting. They soften the bumps that ordinarily make springs strike bottom with that sickening crash. They prevent the recoil that tosses the passengers against the roof. They make the cars you sell ride easier, go faster and last longer.

And here's something that you may not have realized. While Houdailles are one of the highest priced (and most profitable) shock absorbers in the world, they are not the most expensive. If a car owner says he can't afford them—remind him that they are a permanent investment in riding comfort. They have definite trade-in values at the end of one, two and three years.

They not only make your cars last longer but they last long themselves. There are no springs, straps or cables to break. They operate in fluid under pressure.

They are made for all makes and models of light, medium and heavy cars. You do not have to carry a stock nor invest any money in them. The Houdaille Distributor will gladly explain the exclusive patented features of the World's Finest Shock Absorber, or write direct to the factory. The coupon is for your convenience—mail it today.

HOUDE ENGINEERING CORPORATION, *Dept. SAE-6*
537 EAST DELAVAN AVENUE, BUFFALO, N. Y.
IN CANADA : 222 SIMCOE ST., TORONTO, ONT.

Please send me the facts on Houdaille Sales and how I can become a Houdaille Dealer.

Name .....

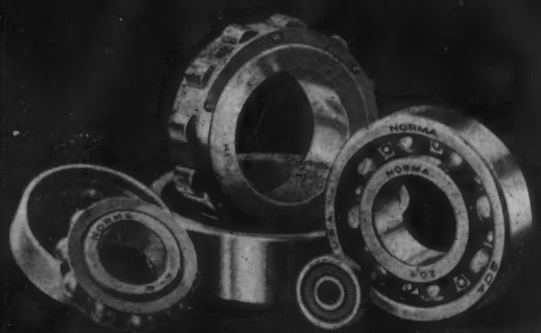
Address .....

.....

NORMA-
HOFFMANN
PRECISION
BEARINGS

THE results achieved with "Norma" Precision Ball Bearings, with "Hoffmann" Precision Roller Bearings, or with the two in combination, have never yet failed to justify the judgment of the engineers and designers who specified them.

NORMA-HOFFMANN
BEARINGS CORPN.
Stamford, Conn.



N-21

Personal Notes of the Members

Concluded

J. G. Monjar, sales engineer of the Hyatt Roller Bearing Co., Detroit, for 12 years, has accepted the position of sales manager for the Detroit Gear & Machine Co.

M. Mukerjee has left the service of Dodge Brothers, Inc., Detroit, where he was employed as designer, to study mechanical engineering in the University of Michigan.

F. J. Niedermiller has been made district sales manager of Gears & Forgings, Inc., Cleveland, successor to the William Ganschow Co., Chicago, of which he was sales engineer.

Herbert N. Nigg has resigned as president of the Republic Gear Co., Detroit, to establish a similar connection with the Piston Service Co., Inc., located in the same city.

I. Patrick has become affiliated with the Rockford Iron Works, Rockford, Ill. He was formerly assistant chief engineer of the E. W. Bliss Co., Brooklyn, N. Y.

Braxton Rhodes, formerly engineer officer at the Naval Air Station, Pensacola, Fla., has been appointed assistant assembly and repair officer on the U. S. S. Lexington.

Arthur R. Schmidt has accepted a position as checker of drawings for the W. A. Jones Foundry & Machine Co., Chicago. His prior connection was as draftsman with the William Ganschow Co., of the same city.

Otto R. Schoenrock recently organized the O. R. S. Engineering Co. in Chicago to engage in tractor and motor-truck engineering. He holds the title of chief engineer of this company. Previously Mr. Schoenrock was chief engineer in the gas-power engineering department of the International Harvester Co., also of Chicago.

Carl F. Scott, formerly manager of building-equipment sales for the General Electric Co., Schenectady, N. Y., has entered the service of the Gurney Elevator Co., New York City, as assistant sales manager.

M. H. Supy, who was previously district service manager of the Atlanta, Ga., branch of the Studebaker Corporation of America, has been transferred to Philadelphia.

J. J. Tobias, equipment sales manager of the Moto-Meter Company for the last 12 years, with offices at Detroit, has been elected vice-president of the company.

Ralph Upson, until recently chief engineer of the Aircraft Development Corporation, Detroit, is now employed as consulting engineer by the same company.

Th. M. van der Stempel has been appointed European commercial-car representative for the Studebaker Corporation of America, South Bend, Ind., his headquarters to be in Brussels.

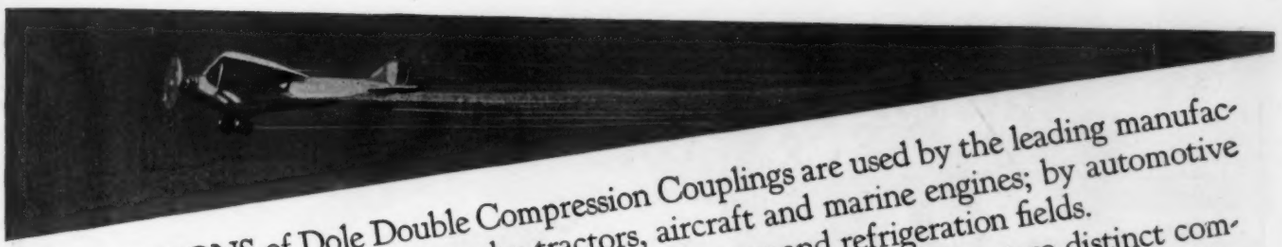
Ernest K. von Brand has started on an expedition to Asia Minor for the purpose of making excavations for prehistoric research under the direction of the Oriental Institute of the University of Chicago. He will be engineer for the maintenance of cars and machinery. Prior to this undertaking Mr. von Brand was experimental engineer for the Fedders Mfg. Co., of Buffalo.

E. H. Webster recently resigned as vice-president of the Southern Fire Apparatus Co., Dallas, Tex., to become assistant department manager of the fire apparatus division of the W. S. Nott Co., of Minneapolis.

D. F. Wheeler, who until lately was president of the Wheeler-Schebler Carburetor Co., Indianapolis, is now associated with the Langsenkamp-Wheeler Brass Works, Indianapolis.

Walter F. Whiteman has resigned his position as research laboratory assistant for the Studebaker Corporation of America, South Bend, Ind., to join the engineering staff of the Monroe Auto Equipment Co., Monroe, Mich.

John Le Roy Williford, who has been studying mechanical engineering in the University of Illinois, will become manager of the Williford Out Door Advertising Co., Mount Carmel, Ill., on June 15.



MILLIONS of Dole Double Compression Couplings are used by the leading manufacturers of automobiles, trucks, tractors, aircraft and marine engines; by automotive equipment manufacturers and leaders in the oil burner and refrigeration fields.

The device consists of two parts, the body and the screw. There are two distinct compressions: first, where the screw engages the radius in the body, and second, where the tubing meets the V slot in the body. This is the combination which so successfully combats the vibration demon. There is no key nut to work loose.

The coupling is "reconnectable." It can be tightened up and a truly leak-proof union established; it can be loosened (with a wrench), taken apart and then reconnected—again the perfect union. There are no collars, no sleeves, no flaring, no brazing, and no soldering.

Approved by the National Board of Fire Underwriters.

DOLE VALVE COMPANY, 1933 Carroll Ave., Chicago, Illinois

Dole

DOUBLE COMPRESSION COUPLING

From coast to coast the word is spreading.. ROYAL CORDS are better today than ever. They have *everything*... Mileage.. Comfort.. Tough Tread.. Speed.. Road Grip.. Appearance..

UNITED STATES RUBBER COMPANY

Trade Mark

.... and makers of many of the finest American cars capitalize public opinion by specifying U. S. Royals as standard equipment

U.S. ROYAL CORDS

No better tires made today

Trade Mark

United States Rubber Company

"Better looks *mean* better sales!"

"If you want it to sell better, Mr. Wilson, make it look better"

MAKE your product *look* better and you will make it *sell* better. For it's the eye that buys . . . every time. Looks . . . details . . . fineness of finish . . . these are things that close sales. They have come to mean more than small differences in price.

Perhaps it is a Dahlstrom Moulding that will give that telling touch of clean cut good looks to your product. And standing behind the good looks of Dahlstrom Mouldings is the sterling Dahlstrom quality that makes them enduring.

DAHLSTROM METALLIC DOOR CO.
INCORPORATED 1904
JAMESTOWN, NEW YORK

NEW YORK, 475 FIFTH AVE — CHICAGO, 19 SO. LASALLE ST.
PHILADELPHIA, 514 BULLETIN BLDG. — CLEVELAND, 684 THE ARCADE
DETROIT, 2-228 GENERAL MOTORS BLDG.

Representatives in principal cities

Automobile Mouldings:
- Garnish Mouldings
- Windshield Tubing
- Instrument Panels
- Glass Channels
- Floor Moulding
- Finishing Moulding

Architectural Shapes

Mouldings and Shapes for:
- Electric Signs
- Mail Chutes
- Metal Furniture
- Show Cases
- Store Fronts
- Railway Cars
- Auto Buses
- Auto Trucks
- Safes, etc., etc.

Metal Doors and Trim

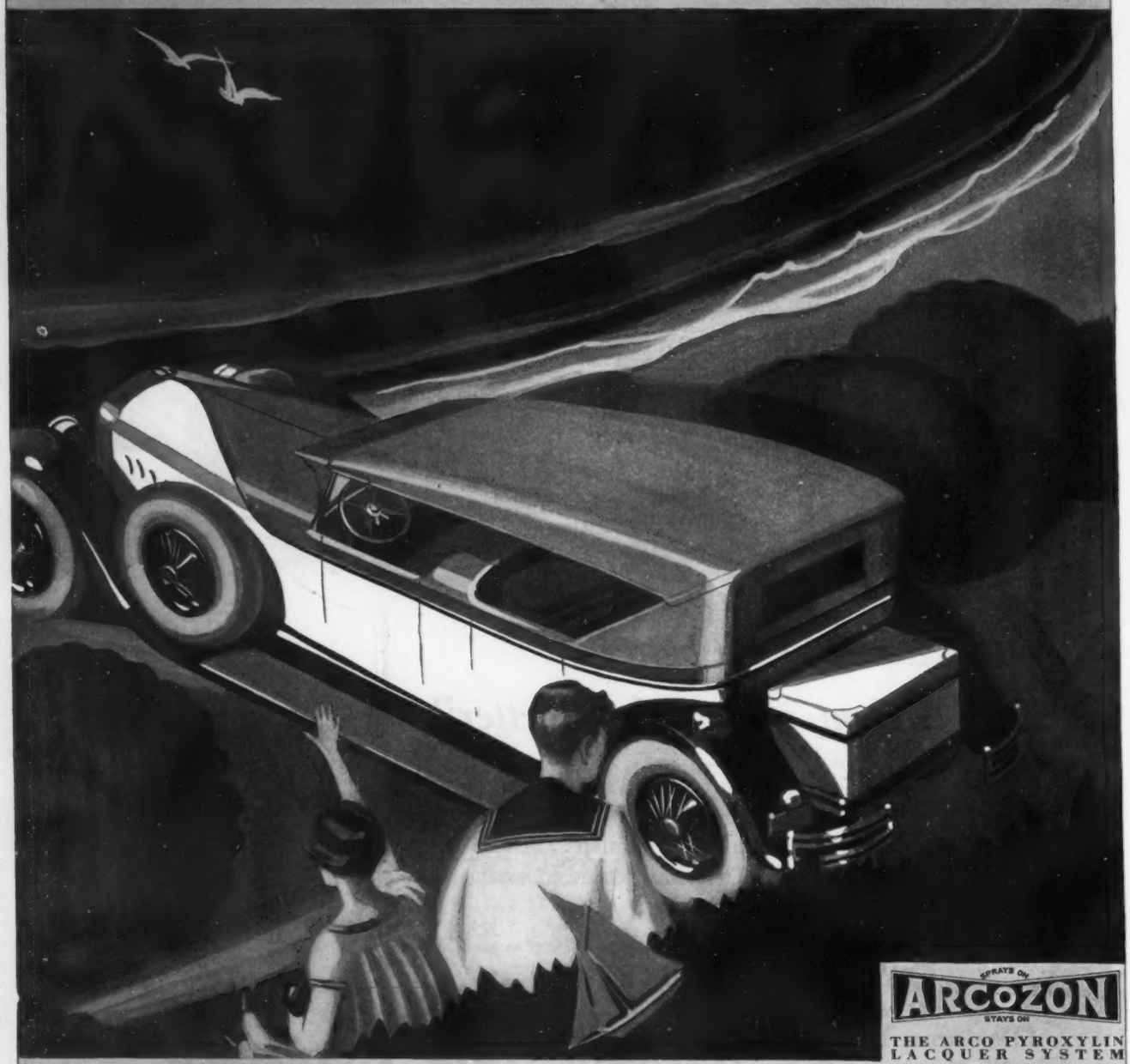
Elevator Inclosures

DAHLSTROM PATENT DOOR — ARTISTIC EVERLASTING SANITARY & FIREPROOF

DAHLSTROM
Metal Shapes & Mouldings

DAHLSTROM PATENT DOOR — ARTISTIC EVERLASTING SANITARY & FIREPROOF

DEFIES WEATHER



SPRAYS ON ARCOZON STAYS ON

THE ARCO PYROXYLIN LACQUER SYSTEM

In Arcozon, we have developed a finish that retains its bright, velvety lustre in spite of the most severe and extreme weather and temperature conditions.

When we were formulating this lacquer, we kept in mind that the most satisfactory automobile finish should endure in spite of rain and snow, beating sunshine and clouds of gritty dust. When Arcozon was definitely proved to meet these demands . . . only then were we satisfied to place it on the market as a perfected pyroxylin lacquer finishing system.

In addition, we developed in Arcozon a number of advantages of application that will interest manufacturers of quality products . . . advantages that assure very definite production economies.

We will be glad to send a man from our technical department to give you complete information . . . and conduct any tests you may specify.

With all the facts at hand you will understand why more and more manufacturers are adopting Arcozon as a standard finishing method. (167)

THE ARCO COMPANY • CLEVELAND, OHIO • *In Canada* • THE ARCO CO., LTD., TORONTO, ONT.

PAINTS VARNISHES ENAMELS LACQUERS

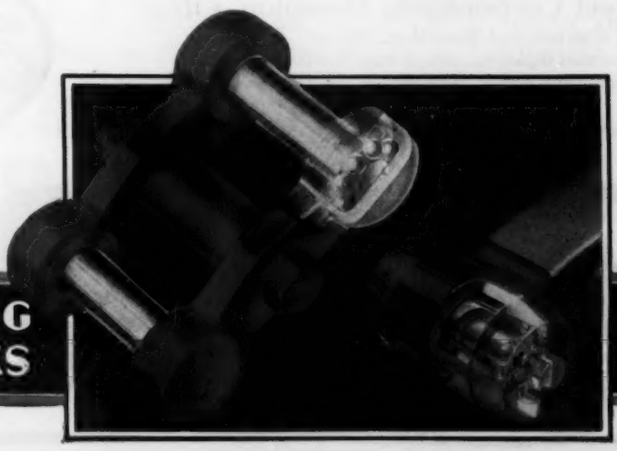
SILENT STRENGTH
in these Spring Shackles of Steel

STRENGTH to withstand the strain of continued spring action—stamina to resist the ravages of time and weather are combined in the frictionless all steel Fafnir Ball Bearing Spring Shackle.

Banished, forever, are the nerve-racking shackle squeaks and rattles; gone for good is the need of greasing and shackle adjustments when Fafnir Ball Bearing Spring Shackles are on a car.

Spring action is free and uniform, hence shock absorbers work better and the maximum of riding comfort is provided. They make a good car better and easier to sell.

Shackle Division
FAFNIR BEARING CO., New Britain. Conn.
Detroit: 120 Madison Avenue
European Agent: Benjamin Whittaker, Ltd. Aldwych House, London, W. C. 2, England



NO GREASING
NO SQUEAKS

NO RATTLES
NO ADJUSTMENTS

FAFNIR BALL BEARING SPRING SHACKLES

Used in the "Eyes" of the Navy

Vital parts of the Martin Bomber and Scout Plane are made of Agathon Alloy Steels. Built by Glenn L. Martin Company for the U. S. Navy.

LIVES are staked every day upon the dependability of airplane parts. If the engine fails, the pilot's fate is uncertain. To make travel in the air as safe as that on the road, leading airplane manufacturers are using dependable Agathon Alloy Steels. These super steels are as necessary in airplane engines as they are for automobile engines. Their light weight and unusual strength have led leading motor car manufacturers to use them for those automotive parts subject to excessive wear, stress, strain or shock.

Have you a copy of our latest Agathon Alloy Steel Handbook?

We have daily production in our two completely equipped plants at Massillon and Canton in all kinds of Agathon Alloy Steels, such as:

Nickel, Chrome-Nickel, UMA. Molybdenum, Chrome-Molybdenum, Nickel-Molybdenum. Vanadium, Chrome-Vanadium, Chromium, etc.

Deliveries in Blooms, Billets Slabs, Hot Rolled, Heat Treated, and Cold Drawn Bars, Hot Rolled Strips, etc.

Central Alloy Steel Corporation, Massillon, Ohio

Mills: Canton and Massillon, Ohio

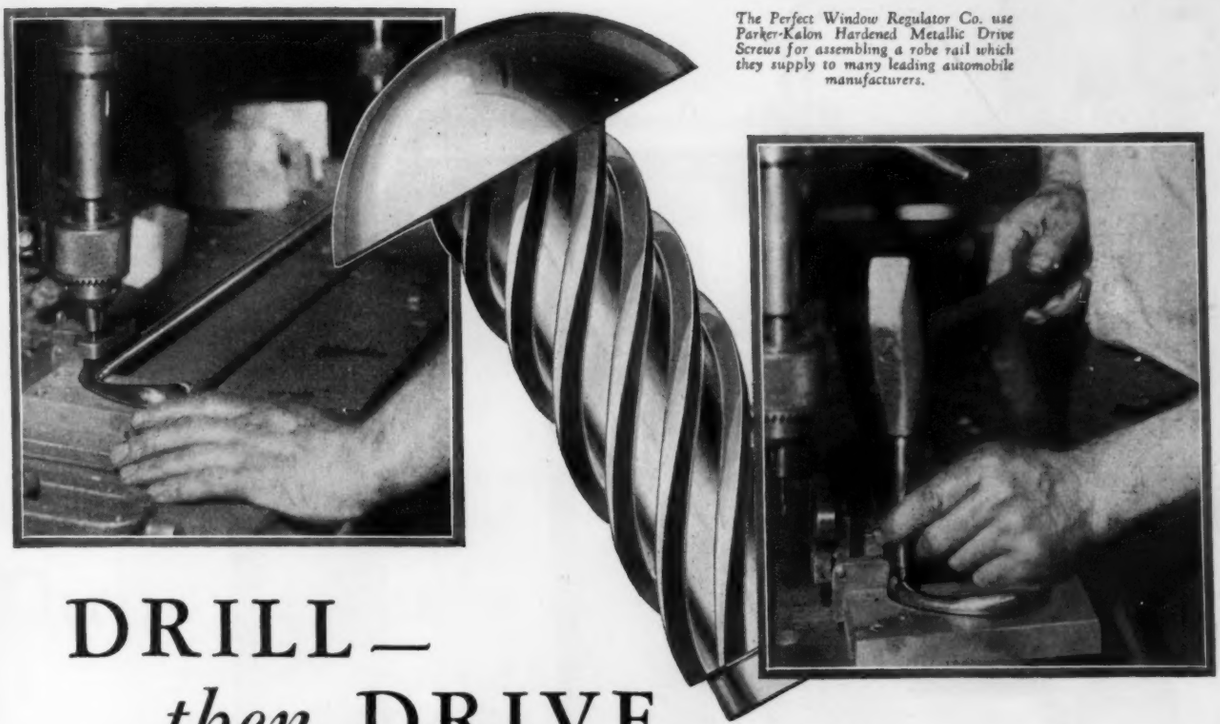
World's Largest and Most Highly Specialized Alloy Steel Producers

Makers of Toncan Copper Mo-lyb-den-um Iron

Cleveland Syracuse San Francisco Detroit Philadelphia Chicago Los Angeles New York Tulsa St. Louis Seattle Cincinnati

ACATHON STEELS

AGATHON ALLOY STEELS



The Perfect Window Regulator Co. use Parker-Kalon Hardened Metallic Drive Screws for assembling a robe rail which they supply to many leading automobile manufacturers.

DRILL— *then* DRIVE— *and it's assembled!*

JUST two simple, inexpensive operations—and the rod and ends of this robe rail are securely assembled with Parker-Kalon Hardened Metallic Drive Screws. This is but one example of scores of assemblies requiring permanent fastenings to iron, brass and aluminum castings, steel, Bakelite, etc., where the use of these remarkable Screws has greatly reduced costs and speeded up production.

Hardened Metallic Drive Screws are so threaded and hardened that they cut their own thread in the material as they are hammered in. They eliminate the costly tapping operation and make better—stronger—fastenings than machine screws, escutcheon pins, etc. Once in, they stay in. Even constant vibration will not loosen them.

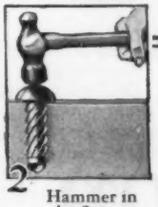
What can better prove their time and labor-saving advantages than the fact that more than 18,000 manufacturers, in every branch of the metal-working industry, are using them.

Fill in and mail the coupon below for samples and full information. Merely tell us what your assemblies consist of and we will send you sufficient samples for test. No charge—no obligation.

Easy to use—

1 Drill a hole.

no skill required



2 Hammer in the Screw.

Parker-Kalon
TRADE MARK
Hardened Metallic
REG. U.S. PAT. OFF.
Drive Screws

PATENTED JAN. 29, 1924 - NO. 1482151
OTHERS PENDING

Parker-Kalon Corporation
198-200 Varick St., New York

Please send me a handful of Hardened Metallic Drive Screws. I want to try them out for

.....

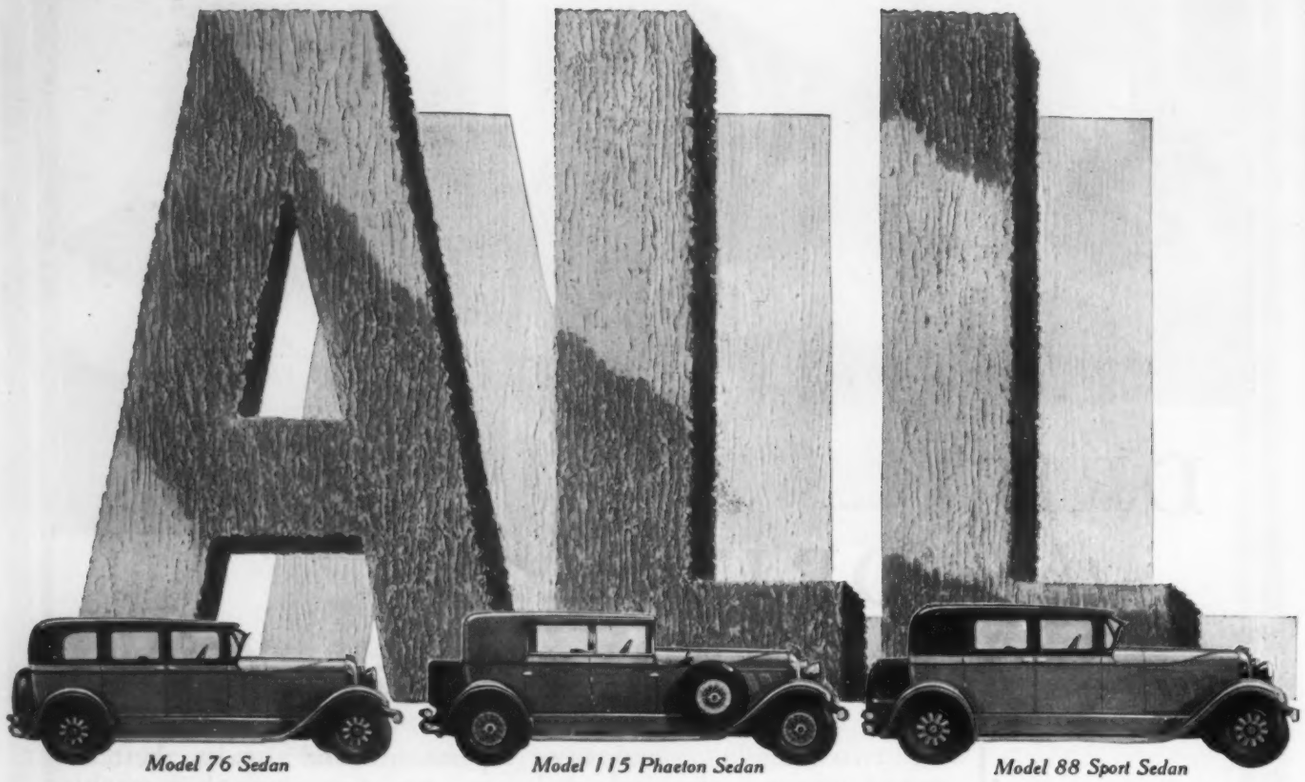
Name .....

Address .....

.....

PARKER-KALON CORP., 198-200 Varick St., New York, N.Y. Distributed in Canada by Aikenhead H'dwre. Ltd., 17-21 Temperance St., Toronto

ON



Model 76 Sedan Model 115 Phaeton Sedan Model 88 Sport Sedan

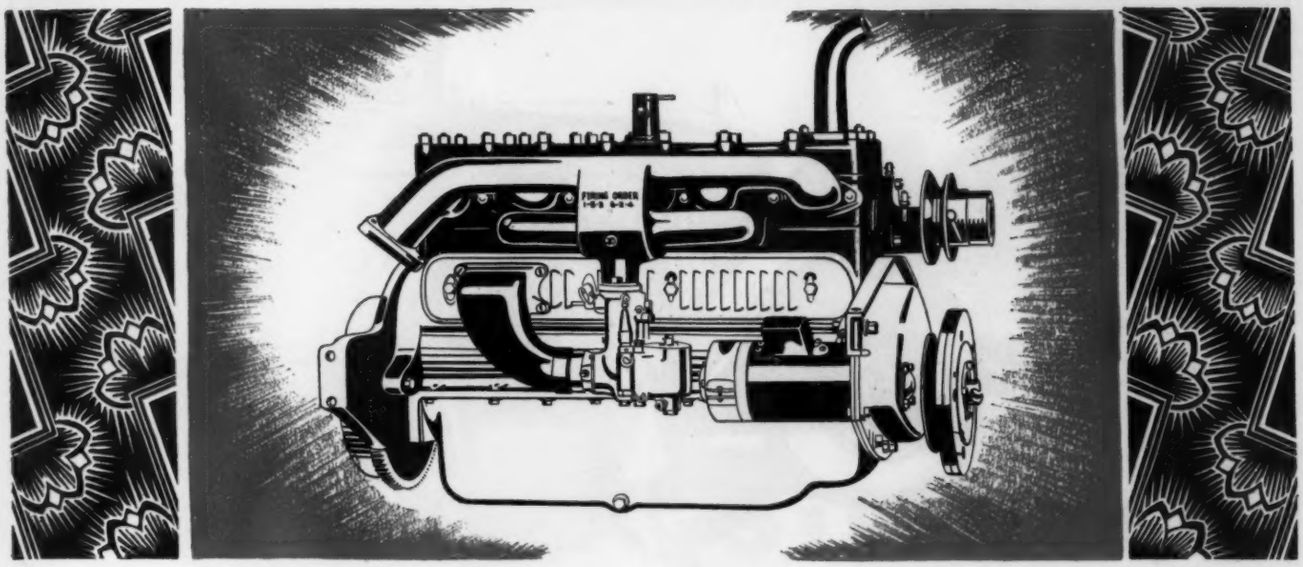
1928 AUBURN *Models*

BIJUR

Chassis Lubrication

BIJUR LUBRICATING CORPORATION, NEW YORK

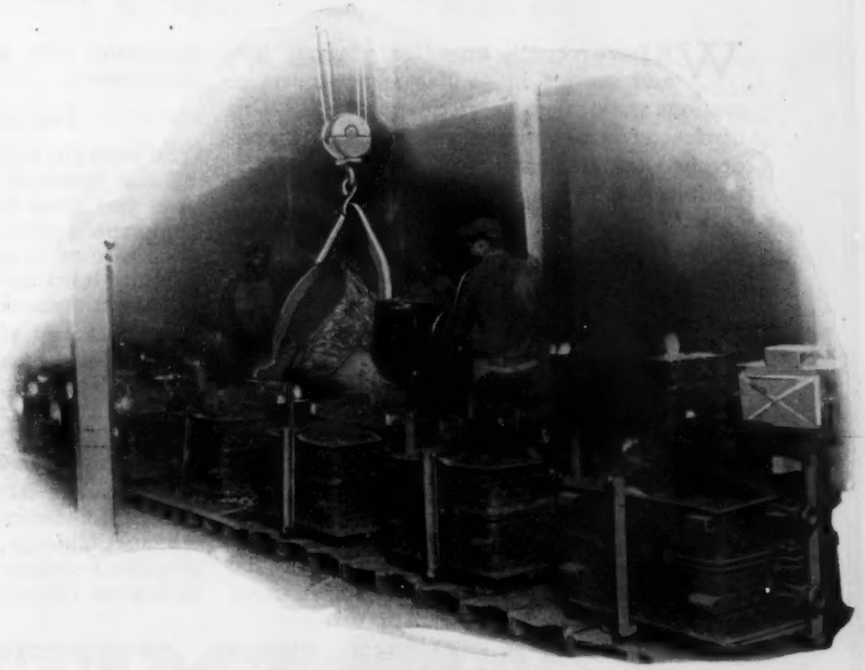
Originators of Modern Chassis Lubrication



Through Years of Stress and Strain

The fact that every Red Seal Continental motor has been built for a particular purpose is one reason for its long life under continuous use. Continental facilities, the most complete in the industry, are utilized to the fullest in the designing and producing of these long lasting, economically operating, gasoline engines.

CONTINENTAL MOTORS CORPORATION
Offices: Detroit, Mich., U. S. A. *Factories:* Detroit and Muskegon
The Largest Exclusive Motor Manufacturer in the World



Moulds on a traveling conveyor pass beneath a huge, cauldron-like ladle. It tips. A tapering, molten stream of metal flows from its spout. The cylinder block has been formed.

Continental Motors

He Cursed *the* CAR

—*But* LACK of LUBRICATION *was the REAL Trouble!*

In just 5 minutes you can prevent this injustice to the cars you sell

WE have recently investigated repair bills and service in 45,000 garages, service stations and dealers' service departments. This disclosed too many cases where the owner condemned the car—and inspection showed the trouble due to improper or neglected lubrication.

Avoid this in 5 minutes
—as you sell the car!

Naturally, you impress upon the new owner the performance and merit of the car he buys. Now take 5 minutes more to insure he keeps on getting all the fine service that's built into it. Don't let him drive off until he understands the importance of regular, proper lubrication! Explain the Alemite system to him thoroughly AND:

Make sure that he comes back to YOU for regular ALEMITE-ING (forcing genuine Alemite lubricant into gears of car—with Alemite equipment).

You cash in two ways

You pave the way to future sales. By guarding against ignorant misuse of the car you sell. And you know from experience that most of tomorrow's sales are built from the performance of cars in use today. This emphasis on Alemite lubrication will go far to make every buyer enthusiastic over your car's performance.

In the second place, you are bringing that owner back once or twice each month for service. Thus you keep in constant touch with him. And this service makes you a net profit of from $12 to $25 per year on each car—your service profit on Alemite-ing!

The Bassick Manufacturing Company Division of Stewart-Warner, 2654 N. Crawford Avenue, Chicago, Ill. Canadian address: The Alemite Products Company of Canada, Ltd., Belleville, Ontario.

ALEMITE
HIGH PRESSURE LUBRICATION

©T. B. M. Co.

Stewart-Warner

THE COMBINED STRENGTH OF THESE TWO NAMES—REPRESENTING THE LARGEST ACCESSORY MANUFACTURERS IN THE WORLD—IS YOUR GUARANTEE OF *QUALITY*

ALEMITE

FIBROC moulded timing gears are perfectly balanced and have tremendous strength.

Added Life and Silence!

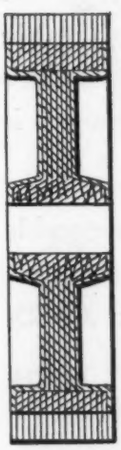
FIBROC

SILENT TIMING GEARS

NOW, nearly all leading Automotive Engineers agree that the driving of timing devices of the modern automobile engine is best accomplished by using an intermediate non-metallic gear.

FIBROC is an extraordinarily good laminated bakelite gear material. This gear material, from actual tests extending over a period of years, has proved to be the best for use in the timing gear trains of high compression high speed motors of today's automobiles.

FIBROC is tough and durable, unaffected by oil and fumes and adds greater silence and longer life to timing gear trains.



FIBROC moulded timing gears are supplied with or without metal hubs—of any design.

The cost of FIBROC gears is no higher than the cost of ordinary silent gears—Specify genuine FIBROC for dependable timing gears.

Note how the heaviest canvas threads all run in the same direction so as to bring the butt ends at the point of impact, thus giving every tooth maximum wear.

FIBROC INSULATION CO.
215 Lincoln Avenue
VALPARAISO, INDIANA

FIBROC

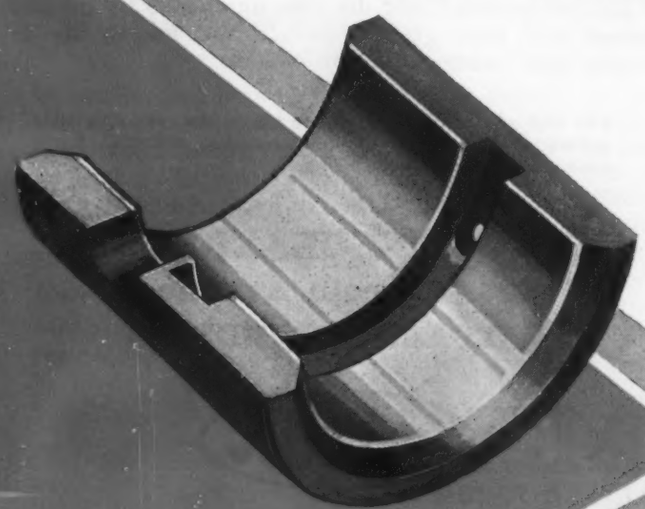
RING TRUE
BOHN
BEARINGS

Headquarters

Always alert to advanced refinements, Bohn engineers developed the Bohn Ring True Interchangeable Bearing which today constitutes 70% of Bohn's Bearing production. Such an outstanding growth is evidence of outstanding worth.

The Bohn Ring True patented process Interchangeable Bearing is machined to precision limits. Maximum variations in essential dimensions does not exceed .00025.

BOHN ALUMINUM & BRASS CORP., DETROIT, MICH.
Also manufacturers of Nelson Bohnalite Pistons and Bohnalite Castings



When you say

"Invar Strut" Pistons

you mean /

Special alloy steel Backbohns —the original Invar Steel Struts —are cast in, to control expansion and maintain satisfactory clearances under all engine operating conditions

NELSON

BOHNALITE

PISTONS

the First -
the Foremost -
the most widely adopted
Invar Strut Piston
in the World

BOHN ALUMINUM & BRASS CORPORATION, DETROIT, MICH.

Also makers of the famous Bohn Ring True Bearings

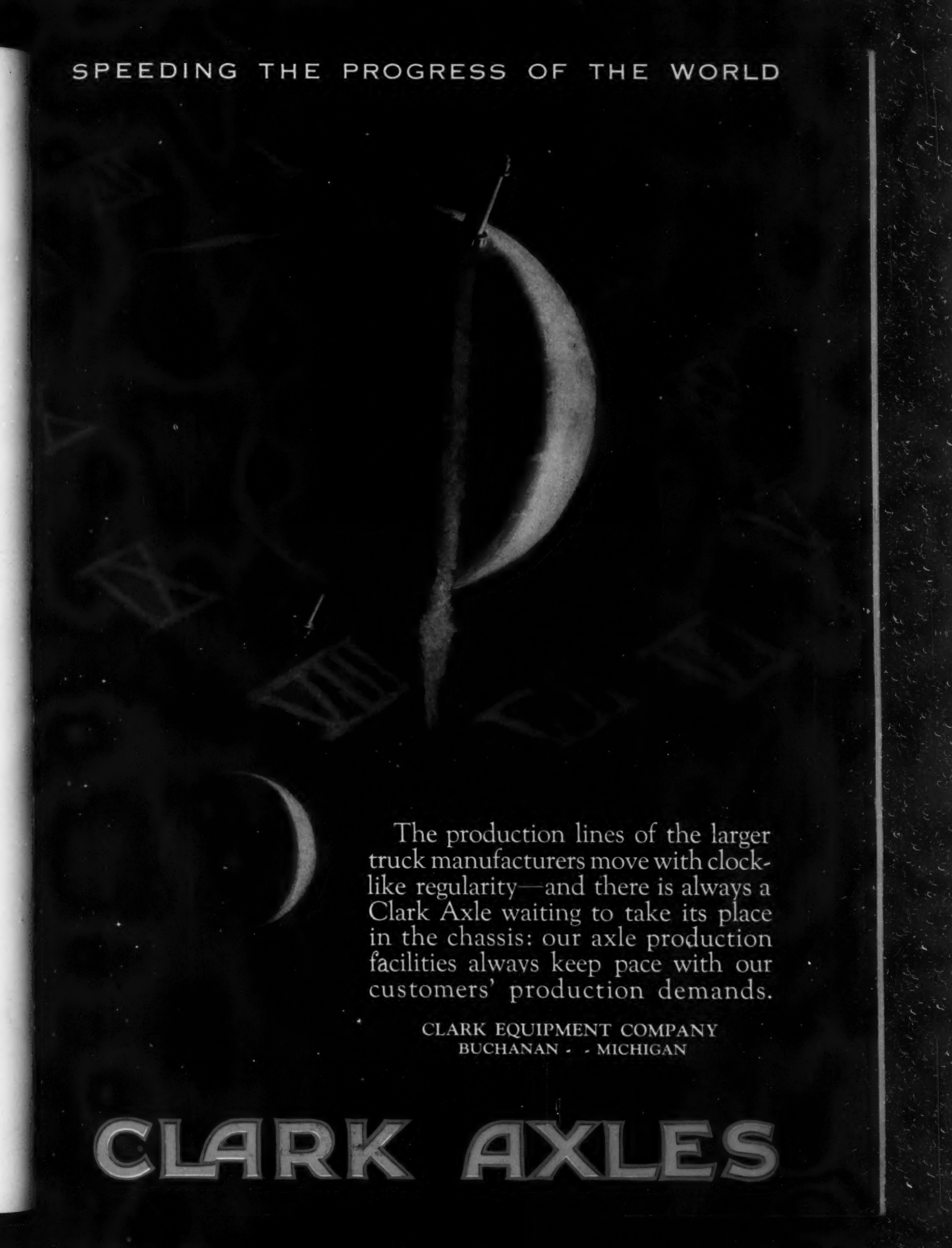
One has only to study the other triumphs of steel over wood to realize that the present trend towards the All-Steel Body was inevitable.

. . .

EDWARD G. BUDD MFG. CO.

Philadelphia and Detroit

SPEEDING THE PROGRESS OF THE WORLD



The production lines of the larger truck manufacturers move with clock-like regularity—and there is always a Clark Axle waiting to take its place in the chassis: our axle production facilities always keep pace with our customers' production demands.

CLARK EQUIPMENT COMPANY
BUCHANAN - - MICHIGAN

CLARK AXLES

CLARK TRUCK WHEELS

Strength of steel, symetry of well designed spokes, lightness of wood, low cost due to large production—tell the story of why Clark Truck Wheels are preferred by the larger truck manufacturers.

CLARK EQUIPMENT CO.
BUCHANAN, MICH.

Reasons for LOCKHEEDS' SUCCESS

Owners of LOCKHEED-equipped passenger cars and trucks will say it is because of the vastly superior performance of these brakes—the ease of application—simplicity of adjustment—low maintenance cost and high wear factor. They will express surprise that all motor vehicles are not provided with equally adequate brakes.

Dealers in LOCKHEED-equipped vehicles will tell you it is because of the demonstrable superiority of these brakes—they help to make sales—they reduce selling costs because they come from the factory ready for delivery and require no attention for many months thereafter. In fact, LOCKHEEDS are in keeping with the high standard of engineering characterizing the car.

These are the primary reasons for the success of LOCKHEEDS, but manufacturers who have adopted them will give you yet another reason, the importance of which may not be fully appreciated.

GREAT ECONOMIES ARE EFFECTED IN THE COST OF PRODUCTION ASSEMBLY BECAUSE OF THE SIMPLICITY OF THE LOCKHEED DESIGN.

What this means to the manufacturer of motor vehicles can only be appreciated by those who have studied the production assembly operations involved in the hydraulic system as compared with those of other designs.

HYDRAULIC BRAKE COMPANY
Detroit, Michigan, U.S.A.

CRAVEROIL *gives*

your Valves a chance to demonstrate how good they are

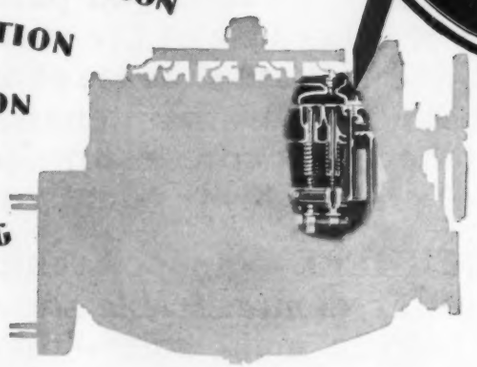
BETTER LOW SPEED OPERATION

QUICKER VALVE ACTION

QUICKER ACCELERATION

GREATER TOP SPEED

NO MORE VALVE GRINDING



The principle of Craveroil *is simply proper lubrication for valves—one of the most vital moving parts of the motor. A* Craveroiler *and* Craveroil *will improve the performance of any motor. Thousands of motorists will verify this.*

A POOR or bad valve is rare today. Modern automobile manufacturers are equipping their motors with the very best valves. Yet they have not eliminated valve troubles. This may puzzle some, but engineers have long realized that the problem is one of lubrication and not design.

The valves in a motor move at a high rate of speed — opening and closing a thousand times a minute. Other slower moving parts are supplied with oil so why shouldn't the valves be lubricated?

The valves are subjected to a very intense heat, especially the exhaust valves. And this is the very thing that recommends *Craveroil* as the only efficient valve lubricant.

Craveroil has a special formula—with lubricating qualities that endure the terrific heats of combustion—so that at high temperatures the valves, valve stems and guides and upper cylinder walls are covered with a coating of *Craveroil.*

The composition of *Craveroil* is such that it will counteract the formation of gums, carbons, and metallic oxides deposited by our modern efficient high-compression fuels. *Craveroil* will also soften and loosen ordinary carbon so that the valves can seat tightly and prevent compression leakage. *Craveroil* will not allow valves to become sluggish.

THIS ENGINEERING DATA IS YOURS FOR THE ASKING

Send for your copy of the *Craveroiler Questionnaire.* It gives detailed facts regarding combustion chamber lubrication with complete information as to what *Craveroil* is and how it functions. *Craveroiler Engineers* are at your service at all times.

Manufactured by

Yale & Towne Mfg. Co.

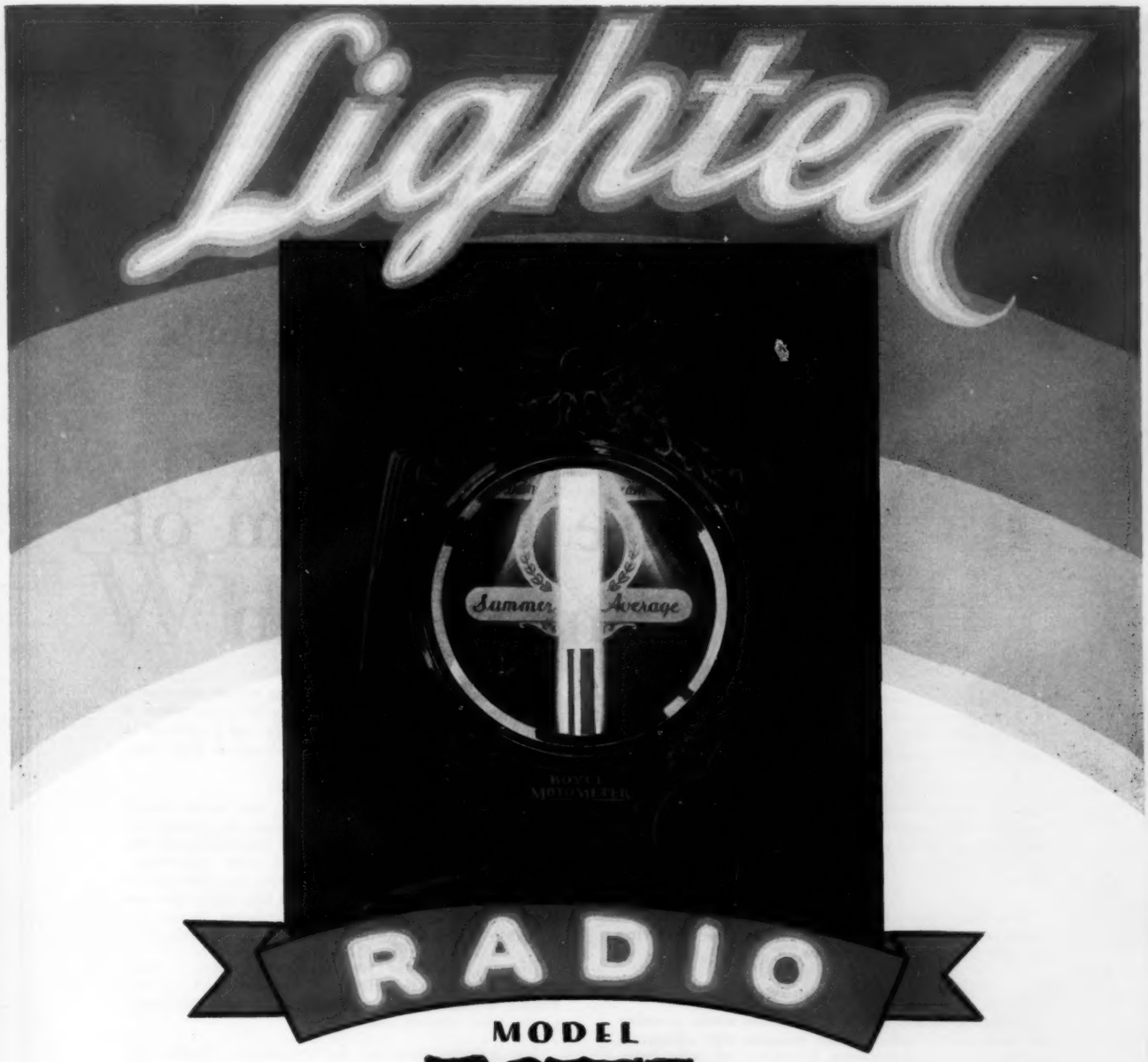
Distributed throughout the world by

Craveroiler Co. of America

4523 Tacony Street Philadelphia, Pa.

CRAVEROILER

THE COMBUSTION CHAMBER LUBRICATOR



MODEL

BOYCE MOTO METER

TRADE MARK REG. U.S. PATENT OFFICE

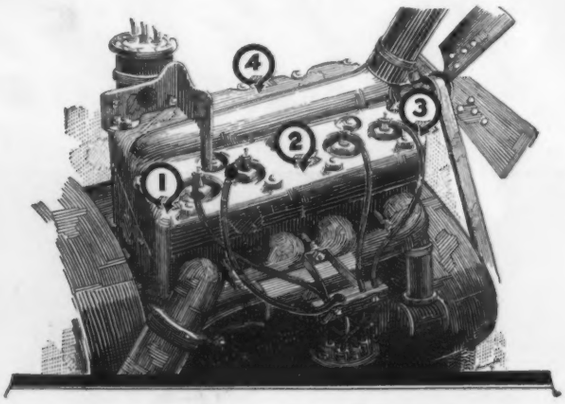
Unique . . . beautiful—and as practical as it is new! Essentially a motor heat indicator, the new lighted Radio model reflects the utmost in motor protection as well as design.

At night, the ingeniously concealed radio pilot bulb throws a soft beam of light down the indicating tube, no annoying glare, yet plenty of light for a constant check on motor conditions!

The transparent crystals, too, are an innovation, completing an effect that adds individuality to the front of any car.

List: $6.50

The Moto Meter Company, Inc., Long Island City, N. Y.



To Meet the Problem of High Compression

HIGH compression now looms up as the most important development of the day. But if it is important as a development it is equally important as a problem.

For years engineers have wrestled with the problem of raising the compression without increasing detonation tendencies. Changes of combustion chamber shapes, spark plug locations and valve arrangements have been resorted to with but slight success.

For this reason the advent of Egalite in use for high compression cylinder heads is receiving marked attention at this time.

Egalite Advantages

Cylinder heads made of Egalite make possible an increase of compression because they eliminate the danger of detonation by more effective combustion chamber cooling.

Egalite eliminates the tendency of hot spotting, or unequalized temperature which produces preignition and overheating. That is because Egalite's heat conductivity is so great that it gives an almost uniform temperature to entire cylinder head.

An actual test upon a running motor showed a variance in temperature of only 8° F between 2 and 4 while a cast iron clyinder head showed a difference of 40° F as indicated upon the illustration.

What Is Egalite?

Egalite is not merely an alloy, but is the result of a special process which equalizes the molecular structure of the metal. Thereby imparting to the metal qualities such as uniform wear resistance, high specific heat and conductivity in addition to its lightness of weight. Practical tests have proven that Egalite contains many attributes especially valuable for many other parts of the automobile.

Pistons, Cylinder heads, Crank cases, Cover plates, Intake and Exhaust Manifolds, Cylinder blocks, Connecting rods, Spring Hangers and supports, Disc wheels, etc.

For anyone desiring to investigate Egalite in connection with any specific problem we furnish complete facilities and information.

Free Egalite Booklet

The Egalite book is a compilation of facts concerning many practical tests which have been made with Egalite and will be sent gladly on request.

The Egal Metal Products Company
Fallsway and Eager Street Baltimore, Md.

EGALITE

for High Compression Cylinder Heads

A Carterized Motor Car Means the Finest in Trimming

Symbols of Excellent Quality . . .

CARTER'S WIRE-ON MOULDING

Carter's WIRE-ON Moulding achieves that final touch of excellency so desirable in today's fine motor cars . . .

The GEO. R. CARTER CO.

Connersville, Ind., U. S. A.

Cut Production Costs With Hutto Grinders

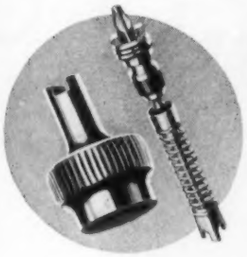
Hutto installation in one of the principal automobile plants

Leading manufacturers are using HUTTO "G" Machines for grinding piston pin holes, hydraulic brake cylinders and similar work. The "G" will do your job, too. Send us your blueprints or ask us to send a representative.

HUTTO ENGINEERING COMPANY, INC.

516 Lycaste Avenue **Detroit, Michigan**

Two parts that fit *any* Schrader tire valve



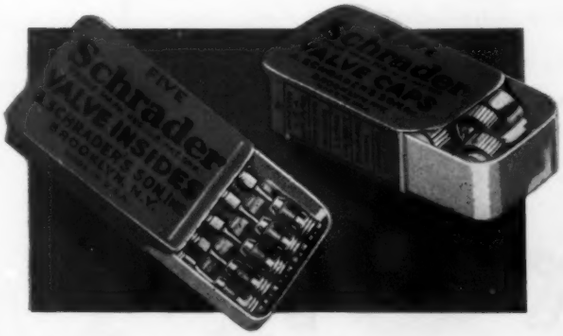
Wherever tires are used, these parts are sold . . . always uniform . . . perfectly interchangeable

SCHRADER Valve Insides and Valve Caps always fit.

You can take a No. 880 Valve Cap from a bus tire and put it on an airplane tire . . . or take a Schrader Valve Inside from a bicycle tire and use it in an automobile tire. No matter what the type of tire . . . no matter what the size . . . these valve parts fit perfectly and are equally dependable for either high or low pressure.

Schrader Valve Insides and Valve Caps can be bought everywhere. More than 100,000 dealers, all over the world, sell these two valve parts . . . parts that are the same in Chicago and Calcutta . . . parts that fit as perfectly in New York as in London.

These features . . . interchangeability, world-wide distribution, uniformity . . . are important reasons why Schrader Tire Valves are the standard of the world.



Schrader Valve Insides and No. 880 Valve Caps are packed for resale in handy metal boxes containing five each.

A. SCHRADER'S SON, INC., BROOKLYN, N. Y.

Branches: Chicago - Toronto - London

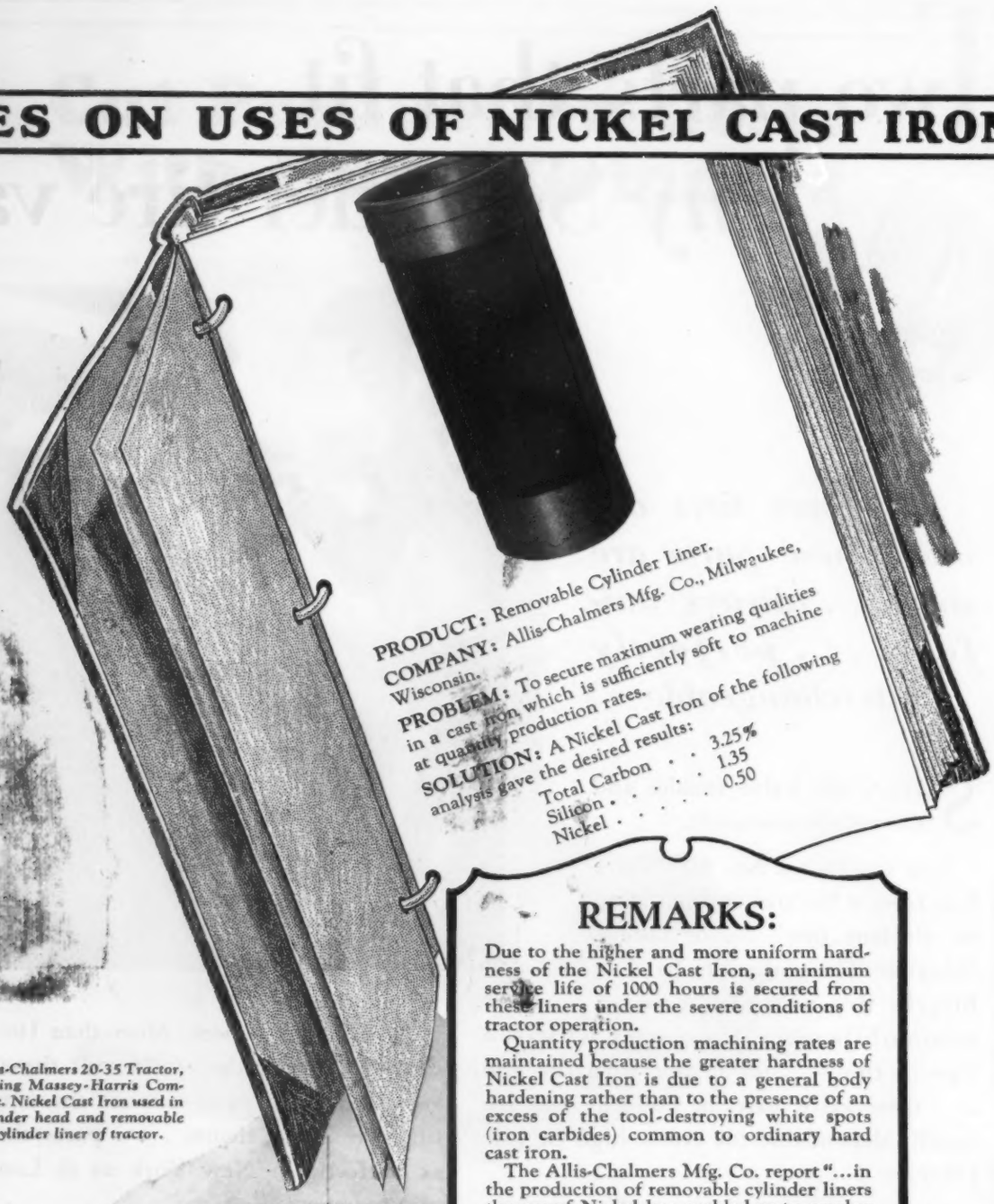
Subsidiaries: Akron - Los Angeles - Paris

Schrader

Makers of Pneumatic Valves Since 1844

TIRE VALVES — TIRE GAUGES

NOTES ON USES OF NICKEL CAST IRON



PRODUCT: Removable Cylinder Liner.

COMPANY: Allis-Chalmers Mfg. Co., Milwaukee, Wisconsin.

PROBLEM: To secure maximum wearing qualities in a cast iron which is sufficiently soft to machine at quantity production rates.

SOLUTION: A Nickel Cast Iron of the following analysis gave the desired results:

Total Carbon	3.25%
Silicon	1.35
Nickel	0.50

Allis-Chalmers 20-35 Tractor, pulling Massey-Harris Combine. Nickel Cast Iron used in cylinder head and removable cylinder liner of tractor.

REMARKS:

Due to the higher and more uniform hardness of the Nickel Cast Iron, a minimum service life of 1000 hours is secured from these liners under the severe conditions of tractor operation.

Quantity production machining rates are maintained because the greater hardness of Nickel Cast Iron is due to a general body hardening rather than to the presence of an excess of the tool-destroying white spots (iron carbides) common to ordinary hard cast iron.

The Allis-Chalmers Mfg. Co. report "...in the production of removable cylinder liners the use of Nickel has enabled us to employ a harder mixture having better wearing properties, which is at the same time sufficiently machinable to meet quantity production requirements."

Our foundry specialists will gladly discuss your casting problems with you.

INCO NICKEL TRADE MARK

Nickel

THE INTERNATIONAL NICKEL COMPANY (INC.) 67 WALL STREET, NEW YORK, N. Y.

"Morse Silent Timing Chain of course"

NO other item of motor equipment has greater sales importance than the timing chain. Tell prospects that your motor is Morse equipped and there is nothing further to say. For fifteen years, Morse Silent Timing Chains have been "Always Quiet—Always Dependable".

"Now that we are using Morse Silent Timing Chains, we've forgotten that our car really has a front end" is the concensus of opinion of motor car manufacturers.

It is that quality of absolute reliability that has earned for Morse Silent Timing Chains such an enviable reputation.

It is that quality which has made them unanimous choice among a big majority of manufacturers using front end chain drives.

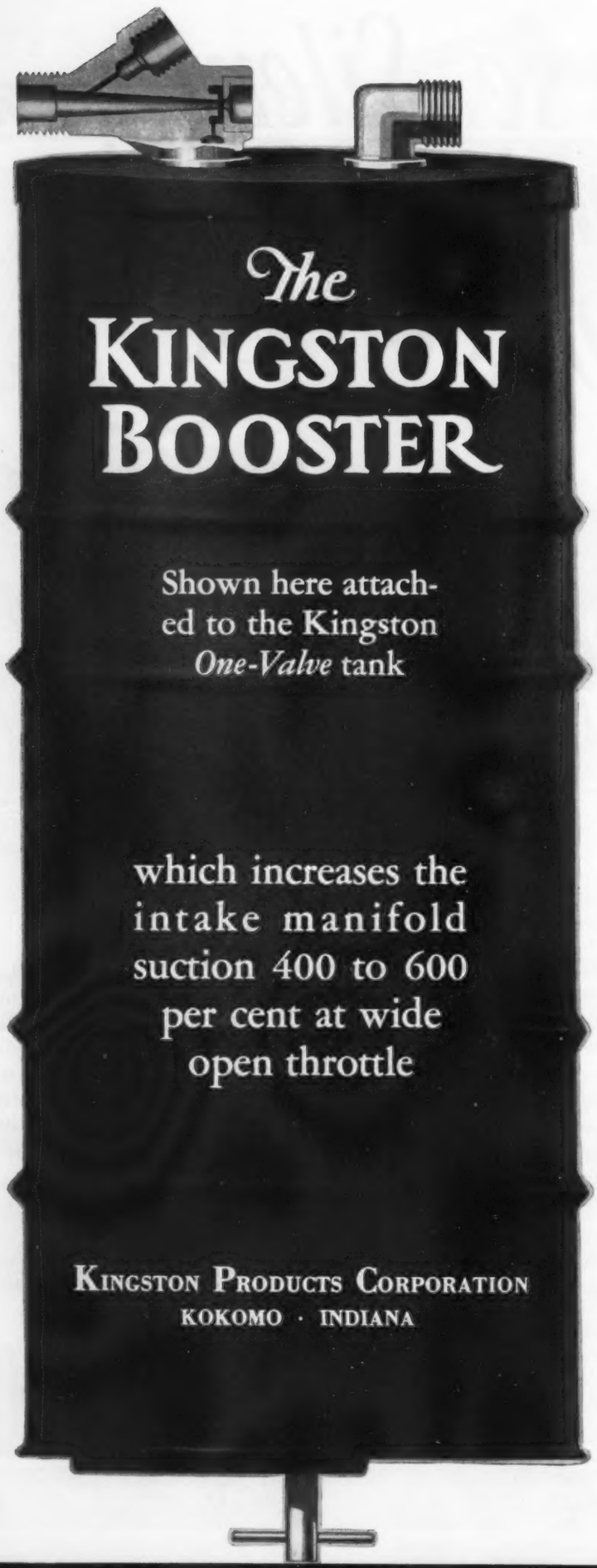
Recent additions at both our Ithaca and Detroit factories have placed us in still better position to meet the needs of the automotive industry quickly and economically.

Ask Morse engineers to help you with your timing chain problems. An inquiry involves no obligation.

MORSE CHAIN COMPANY
Main Office and Works, Ithaca, N. Y.
Sales and Engineering Office: Detroit, Mich.

MORSE

GENUINE SILENT CHAINS


The
KINGSTON
BOOSTER
Shown here attached to the Kingston *One-Valve* tank
which increases the intake manifold suction 400 to 600 per cent at wide open throttle
KINGSTON PRODUCTS CORPORATION
KOKOMO · INDIANA

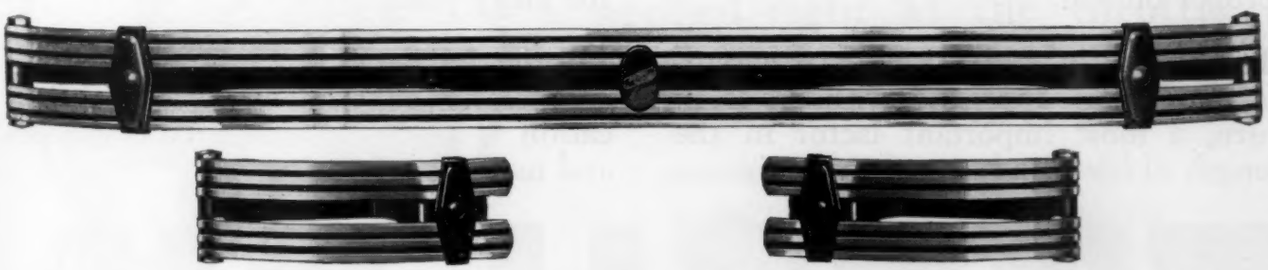
Traffic Tested BUMPERS

THESE are not merely strips of bent metal, built from a price, *in*. They are a known quantity, designed from a purpose, *out*.

How well they will serve is proved in actual Traffic Tests where they are smashed into fire plugs and concrete pillars.

Specify Stewart-Warner Traffic-Tested Bumpers. Their modern lines enhance appearance and their dependability gives salesmen an excelling feature.

STEWART-WARNER SPEEDOMETER CORPORATION, CHICAGO, U. S. A.

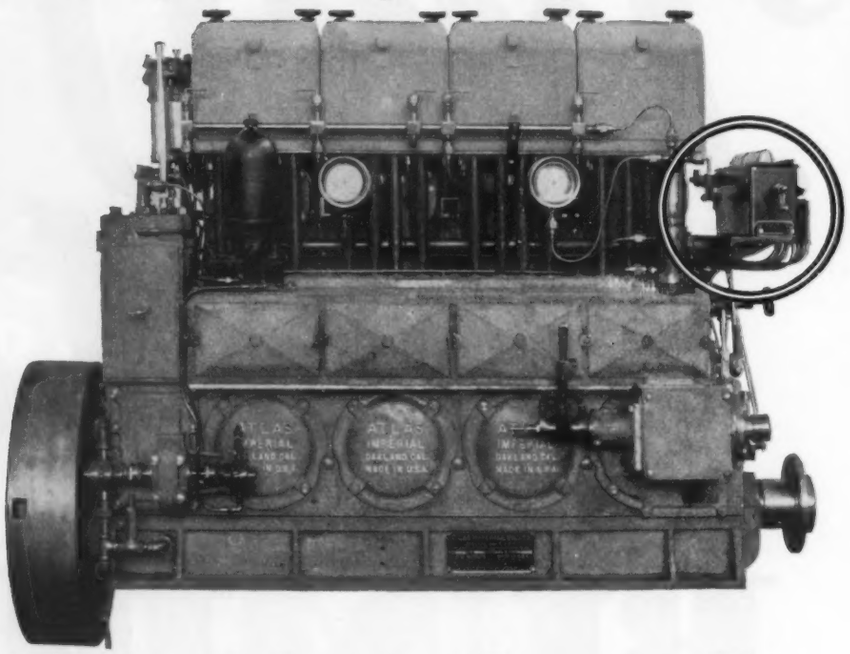


STEWART-WARNER
TRAFFIC-TESTED PRODUCTS

Speedometers ▲ Vacuum Tanks ▲ Horns ▲ Bumpers ▲ Shock Absorbers ▲ Pass-a-Lite, the wireless cigar lighter
Electric and Vacuum Windshield Cleaners ▲ Chains ▲ Driving Lights ▲ Road Lights ▲ Body Polish ▲ Metal Polish

Madison-Kipp Fresh Oil System
for the Cylinders of Heavy Duty Motors

It is noteworthy that Fresh Oil Lubrication of the cylinders has been an outstanding feature of practically every outstanding success on severe service in the heavy duty engine field.



On the ATLAS Imperial $6\frac{1}{2}$ x $8\frac{1}{2}$ *Standard Industrial Engine*

Shown above is the Atlas-4-cylinder 6½ x 8½ Standard Industrial Engine lubricated by the Madison-Kipp Lubricator.

A Heavy Duty Motor can only work to best advantage when the cylinders and pistons are protected by the proper oil-seal.

The quality of the lubricant *at the time it is delivered to the cylinders,* is the most important factor in creating the proper oil-seal.

The proper oil-seal for all bearing surfaces of the pistons and cylinders is, in turn, a most important factor in the length of life of a heavy duty engine.

Madison-Kipp Lubricators unfailingly deliver *fresh oil* in measured quantities to the cylinders.

They start with, run with, and stop with the motor. They provide a proper oil-seal under all conditions of weather and engine performance without waste of oil.

On Atlas engines, Madison-Kipp Lubricators have been standard equipment for many years.

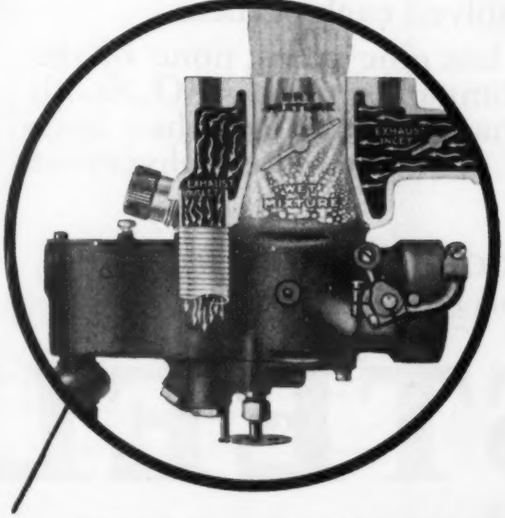
Lubrication data, lubrication service and co-operative experimental work in lubrication is always available to engineers and manufacturers.

FRESH OIL

Madison-Kipp CORPORATION *Lubricators*

Lubrication Specialists Since 1898 *Madison, Wisconsin U.S.A.*

MARVEL
CARBURETION
A Step Ahead



FOR quick starting, fast get away, sustained power, and year 'round efficiency regardless of weather, Marvel Carburetion is always A STEP AHEAD.

Controlled exhaust heat applied right at the throttle (*an exclusive Marvel feature*) guarantees better carburetion.

Standard Factory Equipment on —
BUICK -- NASH -- HUDSON
and OAKLAND

MARVEL CARBURETER COMPANY
FLINT — MICHIGAN

4-wheel brakes, *balloon tires* and new *models*

Every new model has introduced new elements in frame design.

Four-wheel brakes and balloon tires each brought radically new problems.

Higher car speeds have affected it tremendously. Even such changes as new radiators and new body designs have necessitated new methods of approach.

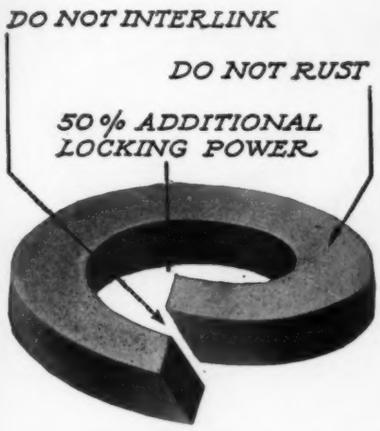
Each of these improvements has brought problems in frame design—problems that had to be solved speedily and under pressure of time.

In co-operation with the customer's engineers, the Smith Engineering Service has met and solved each of them.

Yet, in the last nine years, none of the automobile companies using A. O. Smith frames have had to shut down their lines due to slow or inadequate delivery of frames.

A. O. SMITH CORPORATION, *Milwaukee, Wis.*
Auto Products Division

SMITHSTEEL FRAMES



PIONEERING TO LEADERSHIP

THE first horseless wagons marketed by Ford, Winton and Olds were equipped with National Lock Washers.

That unpretentious beginning led to the ultimate adoption of lock washers by the entire automotive industry.

As the automotive industry grew, the variety of types and sizes became more and more unwieldy until we, in collaboration with A.L.A.M., standardized the product. The present S.A.E. standard is the outcome.

Faced by the problems of today's mass production we invented and patented Kantlink, which eliminated the only major shortcoming of the lock washer, i. e.: its tendency to interlink or tangle.

And then to make Kantlink still better, we Parkerized it to prevent rust.

We are proud of these unusual achievements in the industry.

One way *to reduce* your labor costs

KANTLINK lock washers will save in labor for many manufacturers more than the entire cost of the lock washers. Kantlinks do not interlink or tangle.

Ask your foreman how much time is taken up untangling lock washers. Also ask him how many ingenious contraptions his men have rigged up to keep them from tangling again after they are once untangled. Ask him, too, how many masses of tangled lock washers his men have thrown away "because they cost so little." Then let us send you a supply of Kantlinks for test. Your time and cost sheets will convince you that you cannot afford to use any other type of lock washer.

Furthermore, your finished assembly will be better because Kantlink lock washers are Parkerized so that they will not rust or corrode; and they are cut at such an angle that their locking power is 50% greater than that of the ordinary type of lock washer.

You cannot afford to use anything but Kantlink. And it will not cost much to prove it for yourself. Try some and time the work.

THE NATIONAL LOCK WASHER COMPANY
Newark, New Jersey, U. S. A.

Sales Offices:
BUFFALO, CHICAGO, CLEVELAND, DENVER, DETROIT, LOS ANGELES, MILWAUKEE, NASHVILLE, NEWARK, NEW YORK, ST. LOUIS, ST. PAUL, SAN FRANCISCO,
Canada: TORONTO, MONTREAL

The National Lock Washer Company,
40 Hermon Street,
Newark, New Jersey.
S.A.E.J.—6-28

Please send me information about Kantlink Lock Washers.

(Name)

(Address)

KANTLINK
Trade Mark
LOCK WASHERS

Timken Bearing Rear Axles

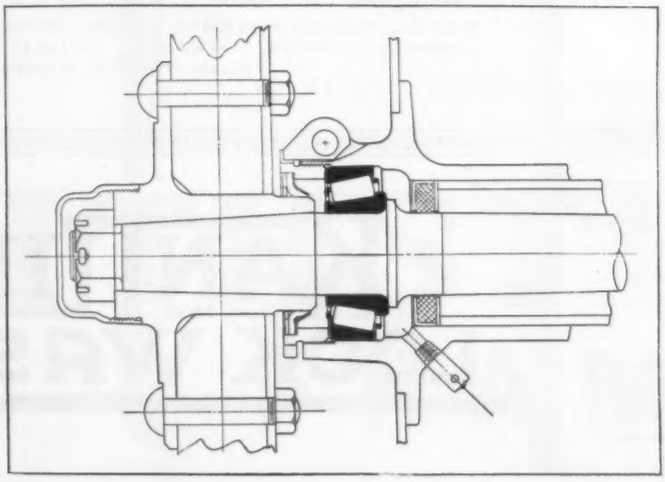
Greater thrust capacity and greater load-carrying area in Timken Bearings account for the improved rigidity of Timken-mounted pinions, differentials, and rear wheels.

Adopting Timken Bearings for the rear axle is a positive step away from noise, service troubles, and ill will. Any engineer can convince himself by means of the same tests which showed several noted manufacturers that Timken Bearings alone meant a 50% reduction in the lift and give of the pinion!

There goes the chief source of noise! There is the sure capacity for modern engine speeds and loads!

THE TIMKEN ROLLER BEARING CO.
CANTON, OHIO

TIMKEN *Tapered Roller* **BEARINGS**



a NEW Piston ERA

1. Trussed and True
2. Head and skirt completely separated but cast in one piece
3. 19,997 of the first 20,000 ✓
4. The lighter they are the faster the car
5. Round and true under all driving conditions.
6. Two and one-quarter times tougher and stronger than iron

✓ Subject of advertisement. (see other side)

A complete series of advertisements will be gladly furnished upon request

TRUSSED AND TRUE

RAY DAY

LIGHT ALLOY

19997

out of the first 20,000-

Of the first twenty thousand Ray Day Piston installations nineteen thousand, nine hundred and ninety-seven *stayed put*—an almost unbelievable record — that is the proof of this New Era piston.

When we say *stay put* we do not mean just long enough to get the car out of the shop, but we mean a durability as enduring as that of iron pistons. Ray Day Pistons do not slap when cold, do not drag when hot and do not pump oil. They set a new standard for piston life.

Ray Day, a fine grained light alloy of very dense structure, is tougher and stronger than any other metal used for pistons, maintaining extreme hardness at all engine temperatures.

RAY DAY PISTON COMPANY
Walton at W. Warren—Detroit

WESTERN FACTORY
27th Ave. and Commodore Way—Seattle

TRUSSED AND TRUE

RAY DAY

LIGHT ALLOY

MAKING RECORDS WITH STUDEBAKER

AGAIN—*Spicer Equipped Cars Establish Record*

Two Studebaker Dictators — strictly stock cars — each recently completed a 5000-mile run in the fast time of less than 5000 *consecutive* minutes — another creditable achievement for Studebaker — another successful run for Spicer.

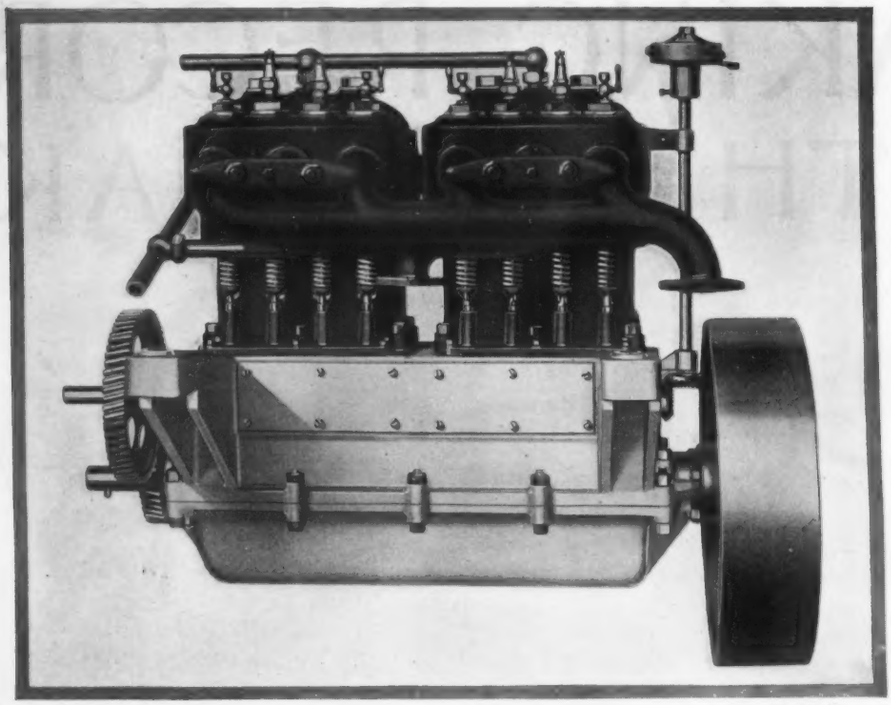
Forty miles an hour when new—65 miles an hour later; unnecessary to change engine oil or lubricate the chassis oftener than every 2500 miles—such is the standard set by the Studebaker Dictator — and met by Spicer Propeller Shafts.

Spicer Universal Joints and Propeller Shafts are standard equipment on these passenger cars:

Cadillac	Erskine	Marmon
Chandler	Flint	Moon
Cunningham	Franklin	Paramount Cab
Dodge—	Gardner	Peerless
Standard Six	Hudson	Pierce-Arrow
Durant	Jordan	Reo-Wolverine
Dupont	LaSalle	Star
Elcar	Lincoln	Studebaker
Essex	Locomobile	Yellow Cab

SPICER MFG. CORP.
South Plainfield New Jersey

Spicer
Propeller Shafts

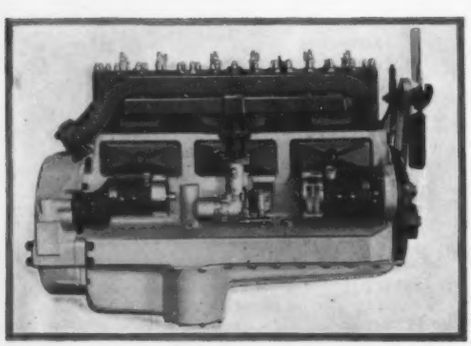


a-826-L

The First Waukesha Engine—40 Roaring Horse Power

The Roaring Forties

More than twenty years of steady progress stand between the first Waukesha engine and the present highly refined powerful coach engines of today. During that period the Waukesha Motor Company has introduced the demountable cylinder head, fully enclosed valve gear, the Ricardo combustion chamber, the truncated non-rocking cylinder block, over-size chrome-nickel steel crankshaft, and the super-rigid "girder" type crankcase, many of which are still exclusive Waukesha advantages.



D-804-S

Today's Quiet, Smooth 120 H. P. Engine

No coach engine is truly modern without at least some of these important features, and only a Waukesha powered coach has them all. To fully appreciate the progress that has been made in this art the small picture at the left shows the present 120 H.P. Waukesha Motor Coach Engine. Send for bulletin No. 592 giving full particulars.

A-843-L

AUTOMOTIVE EQUIPMENT DIVIS ON

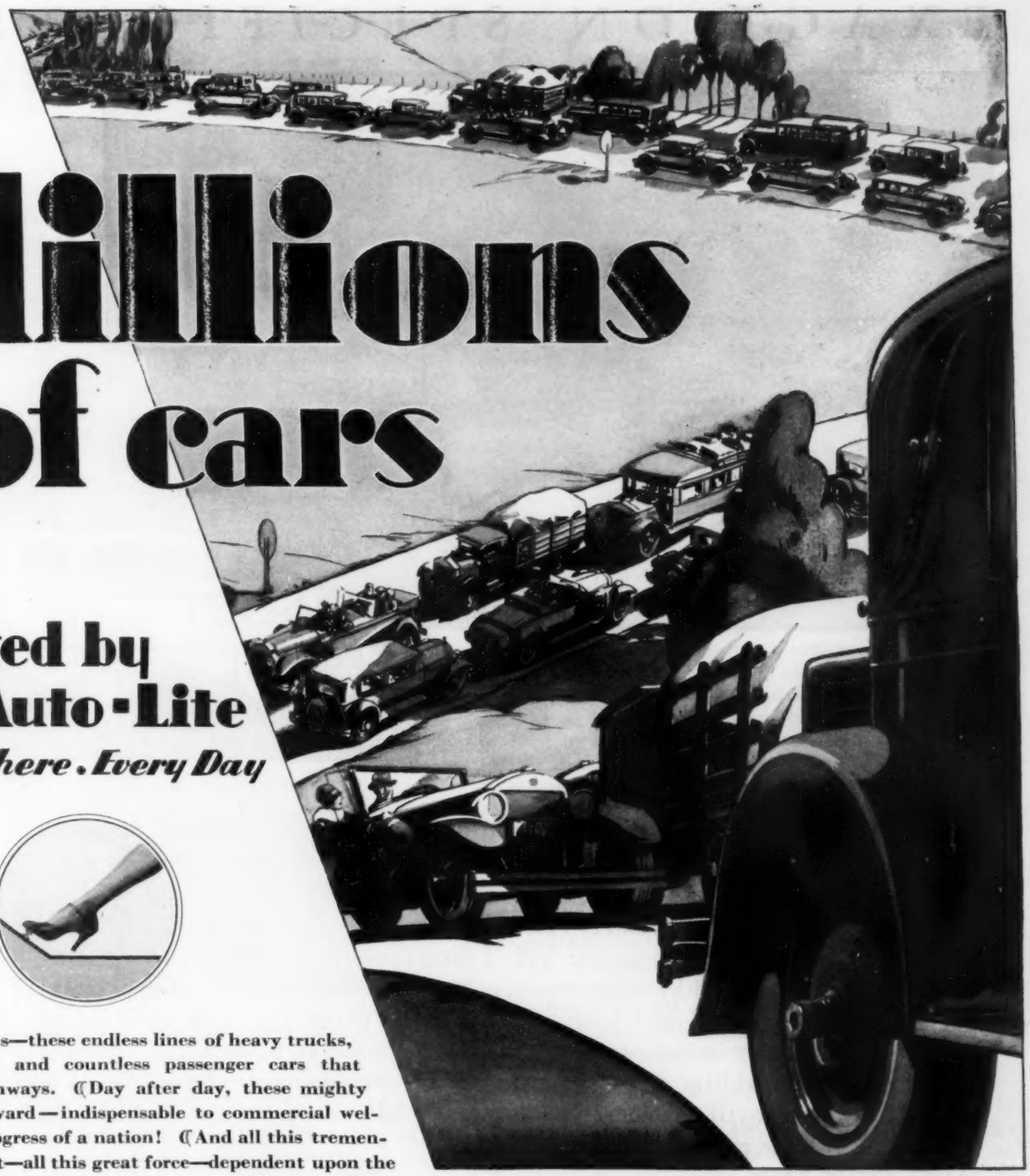
WAUKESHA MOTOR COMPANY

Waukesha Wisconsin

Eastern Sales Offices Eight W. 40th Street New York City

Exlcusive Builders of Heavy Duty Automotive Type Engines for Over Twenty Years

Millions of cars



Started by Auto-Lite

Everywhere . Every Day

Modern caravans—these endless lines of heavy trucks, massive busses and countless passenger cars that throng the highways. ¶ Day after day, these mighty caravans go forward—indispensable to commercial welfare and the progress of a nation! ¶ And all this tremendous movement—all this great force—dependent upon the mechanism of the electrical system. ¶ Years of efficient, faithful service have won for the Auto-Lite starting, lighting and ignition system the confidence of millions of American motorists—and the acclaim of leading motor car builders. Auto-Lite is used by the manufacturers of Durant, Essex, Falcon-Knight, Hudson, Hupmobile, Jordan, Locomobile, McFarlan, Nash, Peerless, Star, Stearns-Knight, Velie, Whippet, Willys-Knight, and many others, including more than 80 Truck, Tractor, and Marine Engine Builders. . . THE ELECTRIC AUTO-LITE COMPANY . . . OFFICE AND WORKS: TOLEDO, OHIO . . *Also Makers of DéJon*

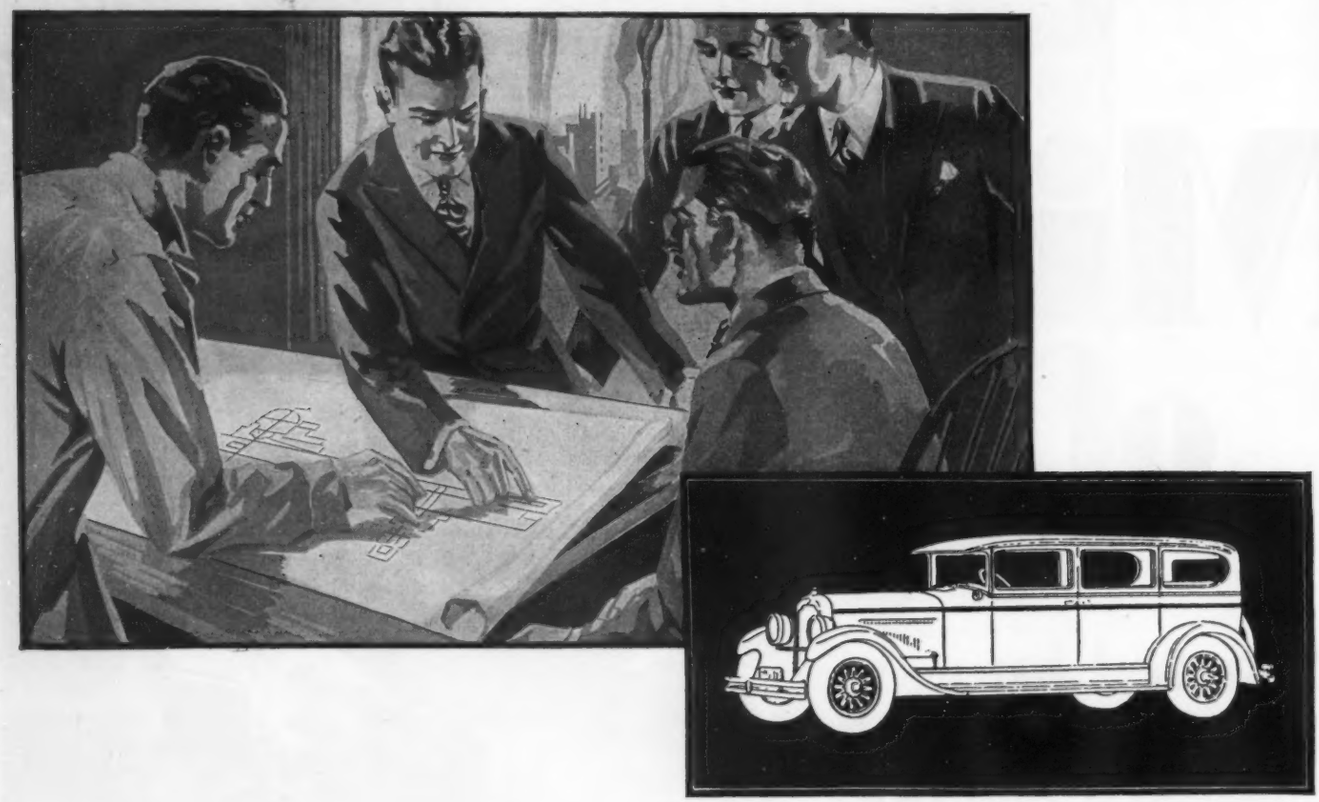
Auto-Lite

Starting, Lighting & Ignition

SERVICE AUTO-LITE STATION

The Sign of Auto-Lite Service— *a national protection for car owners*

EXACT ON SPECIFICATION



IN placing orders for quantity production of parts and completed articles of metal, the automotive business necessarily lays stress on exactness of detail. The modern methods employed by Scovill are guarantees of accuracy. Every process in the three and one-half million square feet of floor space devoted to manufacturing is supervised by trained men. The tools, dies and special machinery are designed and built in the Scovill plant. A high standard of efficiency is maintained. Little wonder that Scovill can combine dependability and speed. For years manufacturers have turned to the Scovill organization for strict adherence to specifications in volume production.

Scovill means SERVICE to all who require parts or finished products of metal. Great factories equipped with the last word in laboratories, and modern machinery manned by skilled workmen, are at your disposal. 'Phone the nearest Scovill office.

SCOVILL

MANUFACTURING COMPANY - - Waterbury, Connecticut

NEW YORK — CHICAGO — BOSTON — SAN FRANCISCO
DETROIT — PHILADELPHIA — LOS ANGELES — ATLANTA
PROVIDENCE — CLE ELAND — CINCINNATI
IN EUROPE—THE HAGUE, HOLLAND

Member, Copper and Brass Research Association

When a woman puts her foot down

SHE EXPECTS RESULTS !

And she would have said "Yes"

His beautiful romance has been shot in the neck. Sweet Agnes-Mae is not going to hook up for the long term with a dub who doesn't know enough to have his brakes lined with Rusco. Have your brakes relined with Rusco today and always be able to stop quicker.

Holds in WET Weather as Well as in Dry

Rusco Brake Lining is treated with a special, Rusco secret compound, so that water has no effect on its efficiency.

Rusco repair men pay more for Rusco than for ordinary lining, but they do not charge you any more. They use special mechanical equipment that insures expert adjustment and application of Rusco. Have your brakes inspected, adjusted or relined today at the nearest Rusco Brake Service Station. Send for free booklet. The Russell Mfg. Co., Middletown, Conn.

Caraguemen: Send today for famous Rusco proposition to the trade

RUSCO BRAKE LINING

One of a series in the Rusco continuous advertising program

Action—quick action—is what the woman driver expects when she puts her foot on the brake pedal.

And that is the kind of action she gets with Rusco lined brakes. Rusco stops quicker, applies with less pedal pressure and holds in wet weather as well as in dry. Women drivers appreciate the feeling of security and smooth, easy brake application that Rusco lining provides.

Millions of motorists have already discovered the quick-stop efficiency of Rusco lining. Millions more are being told about it by the Rusco continuous advertising campaigns.

The adoption of Rusco as standard equipment means adding a quality feature to your cars that is of especial interest to women drivers—and *women buyers.*

The production of a brake lining with the remarkable qualities of Rusco represents an achievement based on 98 years of manufacturing experience and the utilization of the most advanced engineering resources.

Test RUSCO *Yourself*

To prove to yourself, Mr. Car Manufacturer, that Rusco actually measures up to our claims and improves the efficiency of automobile brakes, fill out the coupon below and we shall gladly send you, without charge, enough lining for the brakes of your car.

RUSSELL MFG. CO.,
Dept. B-40, Middletown, Conn.

Please send me free of charge and without obligation enough brake lining to equip the brakes of my car.

Name of car .....

Year .....Model .....

Name .....Position .....

Street .....

City .....State .....

Name of Motor Co. .....

RUSCO BRAKE LINING

Engineers Wanted

Prominent and long established machine tool manufacturer has openings for several practical technically trained engineers. Some of these are wanted for engineering work at the factory and others for training as sales engineers in the field. This is an opportunity for the man of exceptional ability, training and personality to identify himself with an organization recognized as a leader in engineering accomplishment and which is planning for even greater accomplishment during the next ten years.

Applicants must be not over 35 years of age and should write fully of their training and experience. All communications will be treated confidentially.

BOX 14
S. A. E. JOURNAL
29 W. 39th St., New York

"**Good will** is a direct descendant of being decent. It is a deep human response to the higher motives in man.

"**Good will** is public response to a good product, backed up by friendly and efficient service. It comes only to those who deserve it and remains only as long as they deserve it.

"**Good will** is an index of the respect you have earned and the confidence you command. It works on rainy days and dull days.

"**Good will** is our greatest business asset."

Fuller & Sons Mfg. Co.
KALAMAZOO, MICHIGAN

The Summer Meeting Number

Looking forward to our 1928 Summer Meeting Number of the S.A.E. JOURNAL, you will be interested to know that this year it will be the July instead of the June issue as heretofore.

Did you ever attend a Summer Meeting of the Society of Automotive Engineers? This year it will be held at Quebec from June 26 to 29, inclusive, at The Chateau Frontenac. There you will see a cross-section of the readers of the S.A.E. JOURNAL—automotive engineers representing the designing, research and production branches of the industry, and also prominent executives, sales engineers, and operation and service men.

Their activities in automotive engineering developments and in sports and social life at this meeting will be reported in the Summer Meeting Number of the S.A.E. JOURNAL. Interest of these men in this issue is something that every alert manufacturer who sells to the automotive industry wants to draw to his product. (In selling to this industry and keeping it sold, the automotive engineer is a very important factor. He must be sold first, last and continuously.)

As the problems of the automotive manufacturer become better understood, advertisers to this industry appreciate the value of the S.A.E. JOURNAL and use its pages more and more. Over two hundred manufacturers bought space in our last Summer Meeting Number. Our plans for this year's issue are nearing completion, and indicate that the July number will be the most attractive and interesting ever published.

Let us tell you more about the Summer Meeting Number, the interest the automotive industry has in it, and of the industry itself.

Forms close June 15, 1928

Society of Automotive Engineers, Inc.
29 West 39th Street
New York, N. Y.

MECHANICS
OIL LUBRICATED---OIL TIGHT
UNIVERSAL JOINTS

Around the World

without change of lubrication in the Universal Joint would be no unusual performance for a Mechanics.

"Built as only Mechanics Can Build"

Mechanics Machine Co.

Rockford, Ill.

Sales Representative
C. A. S. Engineering Co., Detroit, Mich.

When you think of the good reputation that Interstate Steels have wherever steels are known, think of the years of precise manufacture, constant quality and unfailing service behind that reputation... and we hope you will think it well-earned.

INTERSTATE IRON & STEEL CO.
104 South Michigan Avenue
CHICAGO

Open Hearth Alloy Steel Ingots, Billets, Bars, Wire Rods, Wire, Nails, Cut Tacks, Iron Bars and Railroad Tie Plates

Interstate Alloy Steels

District Offices:

NEW YORK—52 Vanderbilt Avenue
DETROIT—Washington Boulevard Building
MILWAUKEE—First Wisconsin Nat'l Bk. Bldg.
ST. PAUL—Merchants National Bank Building
ST. LOUIS—International Life Building
KANSAS CITY—Reliance Building

Speed With Ease
Getaway
Without Strain

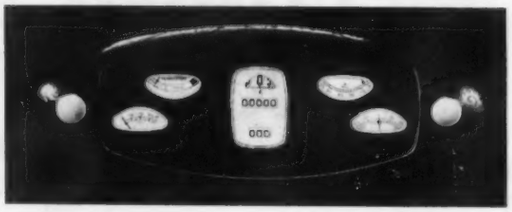
With traffic eight cars wide on the Boulevard, with racing motors ready to jump at the signal light like horses at the post, what other Clutch has responded like the Borg & Beck?

That capacity for delivering "Speed with Ease" and "Getaway without Strain" is what has made the Borg & Beck Clutch predominantly the standard equipment of the industry.

THE BORG & BECK COMPANY

310 SOUTH MICHIGAN AVENUE CHICAGO

DURANT adopts—



NECO *Electric Gasoline Gauge*

COMPANION TO THE NAGEL R-K-D

Nagel Gauges embody 4 distinct features—Accuracy, long life, adaptability and low current demand—all of which have led to their adoption as standard equipment on—

CADILLAC, DuPONT, DURANT 6, ELCAR, FALCON KNIGHT, FRANKLIN, JORDAN, LaSALLE, MARMON, PIERCE ARROW, STEARNS KNIGHT, STUDEBAKER PRESIDENT, WILLYS KNIGHT, VELIE, ACF BUS, GENERAL MOTORS TRUCK, GRAMM BUS, INTERNATIONAL BUS, LARRABEE-DEYO TRUCK, NEBRASKA BUS, REPUBLIC BUS, TWIN COACH, UNION BUS.

THE W. G. NAGEL ELECTRIC COMPANY : TOLEDO : OHIO

NAGEL

AMMETERS • OIL PRESSURE GAUGES
RKD ELECTRIC GASOLINE GAUGES
PANELS • • INSULATIONS OF
HOT MOULDED BAKELITE

AETNA
"RUBBERWARE"
for the
Automotive Industry

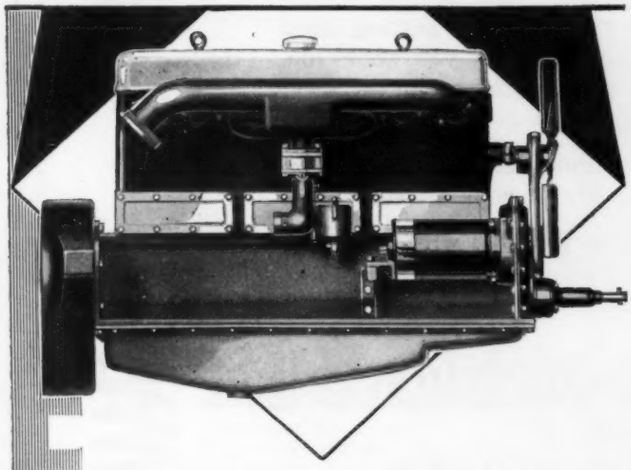
RUBBER ACCESSORIES AND TRIM
MOLDED PARTS MADE TO CUSTOMER'S DESIGN
RUBBER GLOVES

Manufacturers

THE AETNA RUBBER CO.
Cleveland, Ohio

MORE POWER per CUBIC INCH

Power that is *Preferred!*



Note what owners say about the efficiency and economy of Wisconsin Motors . . . . hear why manufacturers of trucks, buses, tractors and construction machinery in highly competitive fields consider it the ideal motor . . . . give a trial motor the acid test of actual performance . . . . and you'll understand why so many specifications include Wisconsin Motors.

We stand ready at all times to substantiate our claims that Wisconsin Motors deliver "More Power per Cubic Inch." No obligation is attached to a request for *proof*.

Wisconsin Motor Mfg. Co.
MILWAUKEE, WISCONSIN

Wisconsin Motors are manufactured in a full line of Sixes and Fours with power ranges from 20 to 150 H.P. for trucks, buses, tractors and construction machinery.

Wisconsin CONSISTENT

WIRE

for the

Automotive Industry

Flat Wire, Strip Steel for Fenders and other Automobile Use. Springs, Ignition Wire, Wire Mesh for Auto Roofs.

Wire for every known Automobile Purpose.

Reliable and Dependable are American Steel & Wire Company's products.

Time and Use has demonstrated this.

For more than a quarter of a century we have been supplying the Automotive Industry with our QUALITY PRODUCTS.

We offer the services of our Engineering departments, and invite correspondence.

Send for our Manual of Electrical Wires and Cables, Springs, Flat Wire and other catalogues describing Wire Products for the Automotive Industry.

Ignition, Starting and Lighting Cables for Automobiles, Airplanes, Tractors, etc.

American Steel & Wire Company

SALES OFFICES

CHICAGO.....208 So. La Salle St.
CLEVELAND.....Rockefeller Bldg.
DETROIT.....Foot of First St.
CINCINNATI.....Union Trust Bldg.
MINNEAPOLIS-ST. PAUL, Merchants Nat'l Bank Bldg., St. Paul
ST. LOUIS.....506 Olive St.
KANSAS CITY.....417 Grand Ave.
OKLAHOMA CITY, First Nat'l Bank Bldg.
BIRMINGHAM....Brown-Marx Bldg.
MEMPHIS, Union and Planters Bank Bldg.
DALLAS.....Praetorian Bldg.
DENVER....First Nat'l Bank Bldg.
SALT LAKE CITY Walker Bank Bldg.
NEW YORK.....30 Church St.
BOSTON .....Statler Bldg.
PITTSBURGH.....Frick Bldg.
PHILADELPHIA.....Widener Bldg.
ATLANTA.....101 Marietta St.
WORCESTER.....94 Grove St.
BALTIMORE.....32 So. Charles St.
BUFFALO.....670 Ellicott St.
WILKES-BARRE.Miners Bank Bldg.
*SAN FRANCISCO.....Russ Bldg.
*LOS ANGELES 2087 E. Slauson Ave.
*PORTLAND.....777 Nicolai St.
*SEATTLE..4th Ave. S. & Conn. St.

**United States Steel Products Co.*

B.G.R.

SPRINGS

Chances are even at any rate that you are getting good springs, promptly and dependably, now. If you would like to get better springs, or want a little more prompt delivery, or a more convenient source, tell us about it.

We believe we can be of real service to the engineer on spring design, and our facilities are at your disposal.

We are equipped to make all types of round wire and small flat springs or any material.

BARNES-GIBSON-RAYMOND Inc.

MANUFACTURERS OF

SPRINGS OF ALL DESCRIPTIONS

6400 MILLER AVENUE

DETROIT, MICH.

Another Victory for Gum-Dipping

207.55 *Miles Per Hour*

Ray Keech, driving the enormous and tremendously heavy 36 cylinder 2500 h.p. Triplex Special, set a new world's record when he averaged 207.5526 miles per hour at Daytona Beach, Florida, April 22, 1928.

Frank Lockhart did not have his car equipped with Firestone Gum-Dipped Tires—and no other cars in the speed trials at Daytona Beach were Firestone equipped, except Ray Keech's car.

MOST MILES PER DOLLAR

Firestone

AMERICANS SHOULD PRODUCE THEIR OWN RUBBER... Harvey S. Firestone

OLSEN TESTING MACHINES

UNIVERSAL TESTING MACHINES for tension, compression and transverse tests of all metals and materials.

HARDNESS TESTING MACHINES for Brinell Hardness tests of all material including sheet metal.

DUCTILITY TESTING MACHINES for determining drawing quality of sheet metal. CEMENT, CONCRETE, CHAIN, ANCHOR, WIRE, ROPE, OIL, PAPER, CLOTH and Rubber Testing Machines.

TORSION IMPACT, REPEATED IMPACT, TOUGHNESS, ENDURANCE, WEAR, ALTERNATE STRESS and EFFICIENCY Testing Machines.

The Standard for Quality the World Over

OLSEN-CARWEN STATIC-DYNAMIC BALANCING MACHINES

Eliminate Vibration—Secure Perfect Balance with Speed and Economy

The Olsen-Carwen is made in many sizes and types to balance any rotating parts from the smallest to the largest rotor made. Now used by all the leading up-to-date automobile and motor manufacturers throughout the country.

SOLE MANUFACTURERS

TINIUS OLSEN TESTING MACHINE COMPANY

500 NORTH TWELFTH STREET
PHILADELPHIA, PA., U. S. A.

FOREIGN REPRESENTATIVES— *Messrs. R. S. Stokvis & Fils, Paris, France, Brussels, Belgium, Rotterdam and Amsterdam, Holland. Edw. G. Herbert, Ltd., Manchester, Eng. Andrews & George Company, Tokyo, Japan.*

The Tool Must Fit The Job

Shop executives no longer expect one type of machine equipment to do every job. They buy different equipment for various classes of work.

The same rule applies in hand tools. An ample stock of sizes and types will speed up production.

The Crescent-Smith & Hemenway line covers a wide range of industrial requirements. Our new catalog will be mailed on request.

CRESCENT TOOL COMPANY
213 Harrison St. Jamestown, N. Y.

CRESCENT
and Smith & Hemenway
TOOLS

Made under the supervision of and guaranteed by the originators of the Crescent Wrench

CELORON
Silent Timing Gears

Now Standard Equipment on 61 Automobile Motors

THE CELORON COMPANY
Division of Diamond State Fibre Co.
BRIDGEPORT, PENN.
In Canada: 350 Eastern Ave., Toronto

Celoron laminated products, molding powders and varnishes are bonded exclusively with Celoron resins. Celoron is the only laminated phenolic material manufactured entirely by one organization under the control of one laboratory.

A Real Magneto

Operates on the inductor principle. Both 20 and 30 degree timing range slots—an exclusive feature.

Water-proof, dust-proof, the Splitdorf Model "B" Magneto provides hot, powerful ignition at all engine speeds and under all conditions of service.

SPLITDORF ELECTRICAL COMPANY
392 High Street Newark, N. J.
Subsidiary of Splitdorf-Bethlehem Electrical Company

Established 1858 — Reg. U. S. Pat. Off.
TRADE SPLITDORF MARK

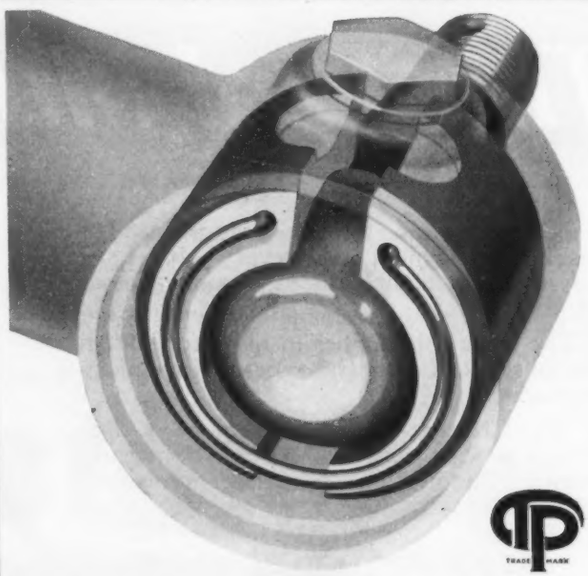
SHULER
FRONT AXLES

Complete Line for TRUCKS Tractors and Trailers

for Motor BUSSES

FRONT AXLES ONLY

SHULER AXLE COMPANY
Incorporated
Louisville Kentucky
Member of Motor Truck Industries, Inc., of America



Thompson Eccentric Tie Rods

The Path of Professional Progress

VENUS PENCILS have been and are constantly being used in making plans and specifications of some of the most important engineering and architectural feats.

Leaders in all professions find that no other pencils quite equal the VENUS for their smooth, firm leads which are absolutely uniform in each degree.

at all stationers and other stores

The largest selling quality pencil in the world

VENUS PENCILS

American Pencil Co.
53 Willow Ave., Hoboken, N. J.

WANTED

An Engineer having considerable experience with automobile accessories, who has some knowledge of patent procedure, to fill a vacancy in the patent department of a large automobile accessory manufacturer. State all qualifications in the first letter.

Box 12
S.A.E. Journal
29 West 39th St. New York

When we Say -
"NO STRAP OR SPRING BREAKAGE"

We Put It in Black and White

For Light Cars Per set of four **$22** For All Others Per set of four **$30**

Manufactured by CHANSON DIVISION
ILLINOIS IRON & BOLT CO., Carpentersville, Illinois

CHANSON
Reg. U. S. Pat. Off.
SHOCK ABSORBERS
CHANSON MEANS CAR COMFORT

Hardness Tests Without Damage

In making hardness tests with Shore's Portable C 2 Scleroscope, the inevitable permanent deformation is microscopic and in no way damages the salability of the product.

Used in testing hardest or softest metals, on pieces of any shape, size or thickness—capacity for 1000 tests per hour makes Shore's New Model C 2 Portable Scleroscope practical for testing parts in production manufacturing.

Easily operated, portable, efficient.

Send for Bulletin 22 for details of this hardness testing method and of the Shore's Scleroscope.

The Shore Instrument & Mfg. Company
Van Wyck Ave., and Carll St., JAMAICA, N. Y.

FOREIGN AGENTS:
Agent for British Empire, Coats Machine Tool Company, Ltd., 14 Palmer St., Westminster, London, S. W. Yamatake & Co., Tokyo, Japan. Aux Forges de Vulcain, Paris, France. R. S. Stokvis & Zonen, Ltd., Belgium and Holland.

DEPENDABLE

In the operation of a complete and modern Felt Cutting Plant at Detroit, as well as four Felt Mills, the American Felt Company has provided the Automotive Industry with an entirely dependable source of supply. Quality, uniformity and quantity are under complete control from the raw wool to the automobile.

American Felt Company

TRADE MARK

Boston Chicago Philadelphia New York
Detroit San Francisco St. Louis

CRANK DROP PARK GUARANTEED FORGED SHAFTS

Counterbalanced

CRANK SHAFTS

and

Heavy Die Forgings

THE PARK DROP FORGE COMPANY
Cleveland, Ohio

THIS Company has been engaged in the production of camshafts exclusively since its inception in 1916 and our organization is composed of men who have become specialists in the operation they are asked to perform in machining and heat-treating them. Equipment developed in this plant makes it possible to turn out experimental work rapidly. Twenty-four hour deliveries after receipt of order frequently being accomplished.

We are in a position to render unusually accurate service in cam production, checking valve lifts in .0001".

A system of double checking pyrometer and test bars insure heat-treating accuracies.

Many of the larger manufacturers are now finding it to their advantage to abandon their camshaft machining departments and let us take care of their production and experimental camshaft problems. We are always glad to assist anyone who is having difficulties with their camshafts.

LO-GORDON MANUFACTURING CO.

MUSKEGON, MICH.

Correct Chassis Lubrication

4 Styles

6 Sizes

Gits Chassis Oilers
are constantly replacing grease fittings because they
DO IT BETTER

Gits Bros. Mfg. Co., 1940 S. Kilbourn, Chicago

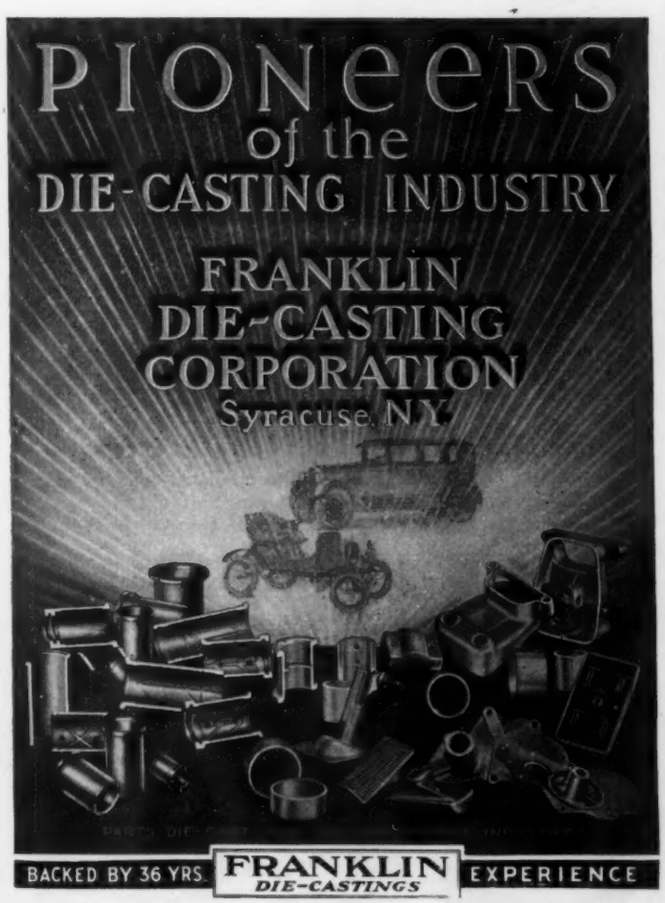
New Process Gear Company
Incorporated
Differential Gear Manufacturers
Syracuse, N. Y.

Adams Axle Company
Axle Manufacturers
Syracuse, N. Y.

Warner Corporation
Transmissions and Steering Gears
Muncie, Ind.

Young technical graduate, age 24 to 30 as assistant to Sales Manager. Must be good correspondent and have some sales ability. Knowledge of motor truck design and operation valuable. Considerable travelling necessary. Write fully concerning education and experience, and state salary desired.

Box 13
S. A. E. Journal
29 West 39th St. New York

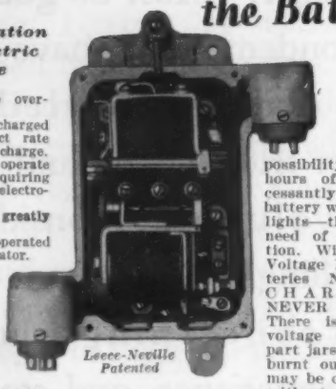


5.30 A.M. — Almost 15 hours of daylight — 8.10 P.M.

Extra running hours are almost sure to overcharge the Battery!

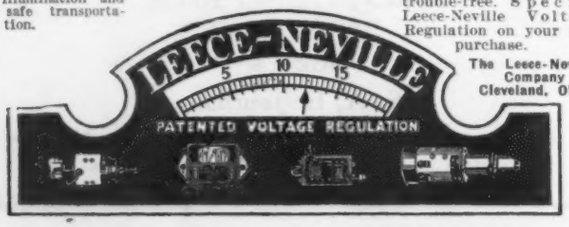
Voltage Regulation Minimizes Electric Maintenance

1. Battery cannot be overcharged.
2. The battery is charged only at the correct rate for its state of charge.
3. Battery will operate longer without requiring replenishing of electrolyte.
4. Life of battery greatly prolonged.
5. Lights can be operated direct from generator.
6. Loose connections will not cause lamp bulbs to burn out.
7. Makes most economical generator system.
8. Any Leece-Neville Voltage Regulated Generator can be used without battery.
9. Lamp life greatly prolonged.
10. Motor coaches fitted with Leece-Neville Voltage Regulated Generators provide passengers with satisfactory illumination and safe transportation.



Leece-Neville Patented

LEECE-NEVILLE Voltage Regulation prevents this possibility. It's the long hours of operation—incessantly charging the battery without using the lights—that proves the need of voltage regulation. With Leece-Neville Voltage Regulation, batteries NEVER OVERCHARGE, generators NEVER BURN OUT. There is no dangerous voltage rise as some part jars loose, no lights burnt out. The vehicle may be operated entirely without the battery. Used by leading truck and bus fleet operators everywhere because it is proven practically trouble-free. Specify Leece-Neville Voltage Regulation on your next purchase.



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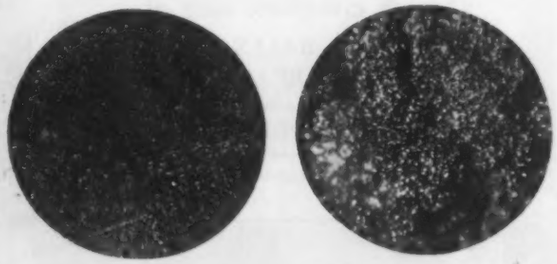

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FOR ALL USES
IN
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OF ALL
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G&O
Radiators

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and
TUBULAR

Large Manufacturing Facilities
Modern Equipment
Prompt Service

THE G & O MANUFACTURING CO.
New Haven Conn.

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FITTINGS

Made from
Brass Rod, Castings
or FORGINGS

We specialize in the manufacture of S. A. E. Standard Flared and Compression type fittings used for connecting brass and copper tubing. Also a complete line of pipe fittings in small sizes. We carry large stocks of the parts most in demand and can supply to advantage similar special parts made from brass rod, castings or FORGINGS.

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DETROIT 5781-5835 COMMONWEALTH AVE. MICH.

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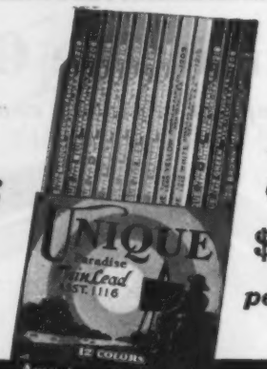

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At all dealers, or send for any color or assorted colors (or the assortment illustrated above) at $1.00 per doz. pencils.

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Single-Row Ball Bearings designed for heavy radial loads will carry thrust loads up to 100% of radial capacity

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Precision combined with speed... lower production costs..increased output... costly hand operations eliminated by *casting holes in the part* to extremely close tolerances.

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For Strength, Lightness, Economy

Non-stop cleaning!

WHEN automotive parts in process of manufacture are cleaned the Oakite way, oil, grease, and dirt are removed quickly. Time required for cleaning stays constant—it is the same one day as another—subsequent operations are not delayed. Then, too, Oakite cleaning is thorough. As a result, rejects are fewer. Production is continuous.

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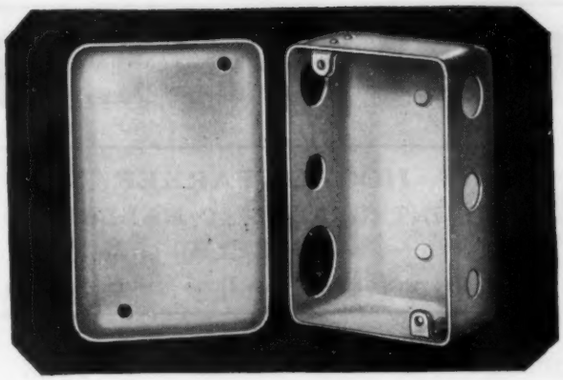
TRADE MARK REG. U.S. PAT. OFF.
Industrial Cleaning Materials and Methods
Oakite Service Men, cleaning specialists, are located in the leading industrial centers of the United States and Canada



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WE USUALLY MAKE THEM
IN LESS OPERATIONS
THAT'S WHY OUR PRICES
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FORGED STEEL
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FOR RUBBER - BOILER - RAILROAD
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NEW WHITNEY CHAIN
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(Patented)

for
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The double interior engaging link designed and developed by WHITNEY engineers is a new and improved feature in chain construction.

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WHEN you require cooperation in the design or other factors associated with the use of Springs, won't you take advantage of our special engineering resources?

Competent Technicians
Practical Springmakers
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Barnes-made Springs
SPRINGS ASSEMBLIES SCREW MACHINE PARTS
STAMPINGS SPRING WASHERS COLD ROLLED SPRING STEEL

A Partnership
for Your Profit
Willard Batteries
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WOOD SPOKE METAL FELLOE
WHEELS
For Use with Single and Dual Solid Tires

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For Use with Single and Dual Pneumatic Tires

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Backed by 45 Years' Experience

AUTOMOBILE TRUCK TRACTOR

COMPLETE HEAT TREATING AND LABORATORY FACILITIES CAPACITY 2500 TONS PER MONTH
ANY TYPE—ANY SIZE—UP TO 500 LBS.

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Titeflex Oil, Water and Gasoline Lines for Automobiles, Trucks and Tractors.

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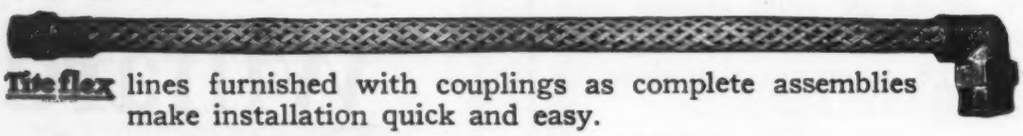
TITEFLEX LINES INSTALLED IN THIS SERVICE.



Titeflex lines furnished with couplings as complete assemblies make installation quick and easy.

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Builders to the most discriminating passenger car and truck manufacturers in the United States and Europe.

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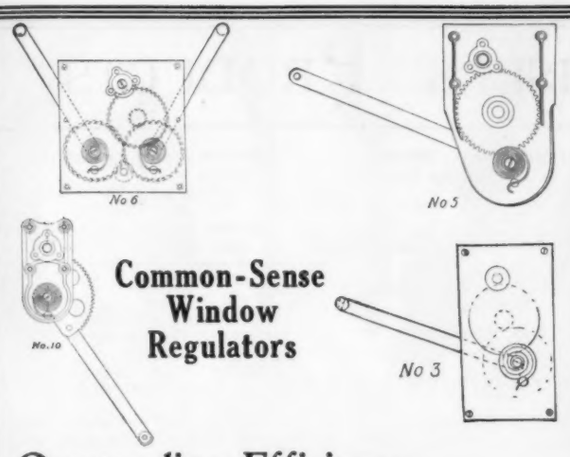
MANUFACTURERS *of* LEAF SPRINGS



Common-Sense Window Regulators

Outstanding Efficiency

and models for every type of window have put the "COMMON-SENSE" window regulators in good standing with the nation's foremost body engineers.
In addition to our standard regulators, we also make "COMMON-SENSE" models for special bodies. Plans and description will be gladly submitted if you will send us blue print or drawing of your custom job requirements.

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Product of

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Factory Branches in 32 Cities

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Houde Engineering Corporation
Stromberg Motor Devices Co.
Watson Co., John Warren

Absorbers, Shock, Hydraulic
Monroe Auto Equipment Co.

Accessories, Punch Press
Danly Machine Specialties, Inc.

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Alloys, Alumino-Vanadium
Vanadium Corporation of America

Alloys, Aluminum
Aluminum Co. of America
Egal Metal Products Co.
Franklin Die-Casting Corporation

Alloys, Babbitt
Federal-Mogul Corporation
Franklin Die-Casting Corporation

Alloys, Brass
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Mueller Brass Co.
Scovill Mfg. Co.

Alloys, Bronze
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Scovill Mfg. Co.

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Vanadium Corporation of America

Alloys, Ferro-Chrome
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Alloys, Ferro-Molybdenum
Vanadium Corporation of America

Alloys, Ferro-Silicon
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Alloys, Ferro-Tungsten
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Alloys, Silico-Manganese
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Copper & Brass Research Association

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Alloys, White Bearing
Franklin Die-Casting Corporation

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Aluminum Co. of America
Franklin Die-Casting Corporation

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Nagel Electric Co., W. G.

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Bosch Magneto Co., Inc., Robert
General Electric Co.
North East Electric Co.

Apparatus, Laboratory
Olsen Testing Machine Co., Tinius

Arc Welding (See Welding Equipment)

Axles, Front, Motor-Truck
Shuler Axle Co., Inc.

Axles, Front, Passenger-Car
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Axles, Motorcoach
Clark Equipment Co.
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Balls, Steel
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New Departure Mfg. Co.

Balls, Steel, Stainless
Hoover Steel Ball Co.

Bands, Steel
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Donner Steel Co., Inc.
Illinois Steel Co.

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Mueller Brass Co.
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Central Alloy Steel Corporation
Link-Belt Co.
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Budd Mfg. Co., E. G.

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Thompson Products, Inc.

Bolts, Stripper
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Bossert Corporation

Brake-Drums
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Bossert Corporation
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Egal Metal Products Co.
Scovill Mfg. Co.

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Federal-Mogul Corporation

Castings, Brass
Bohn Aluminum & Brass Corporation
Mueller Brass Co.
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Mueller Brass Co.
Scovill Mfg. Co.

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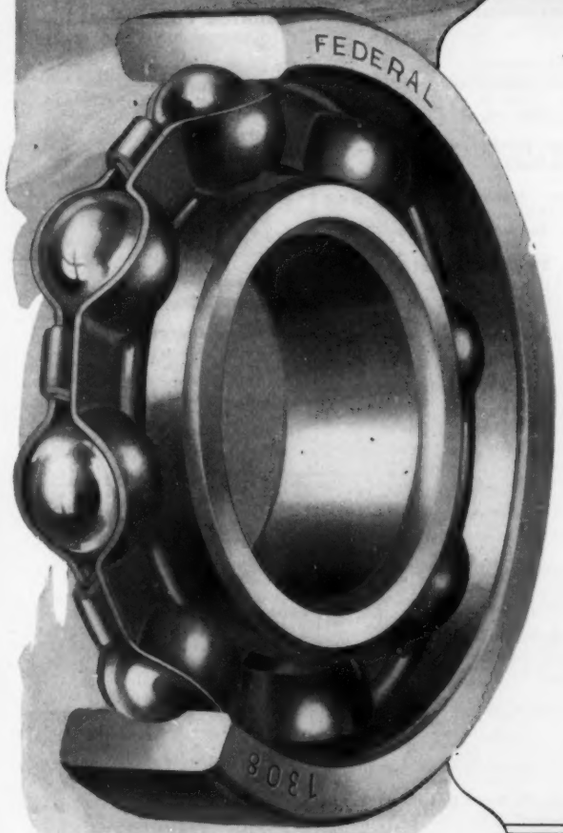
Manufacturers of Products Conforming to S.A.E. Specifications

Advertisers whose products conform to S.A.E. specifications are also listed in the S.A.E. Handbook List of Manufacturers, on page 560, of the 1928 issue of the Handbook.

The addresses of companies listed in this index can be obtained from their current advertisements indexed on page 104.



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Poughkeepsie, New York
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Castings, Malleable Iron
Link-Belt Co.
Timken Roller Bearing Co.

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Castings, Tin Alloy
Federal-Mogul Corporation

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Whitney Mfg. Co.

Chains, Roller
Link-Belt Co.
Whitney Mfg. Co.

Chains, Silent
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Checks, Door
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Chucks
Bullard Machine Tool Co.

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Dynamometers, Engine
General Electric Co.

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Arco Co.

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Gears, Transmission
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Leece-Neville Co.
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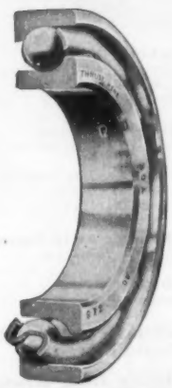

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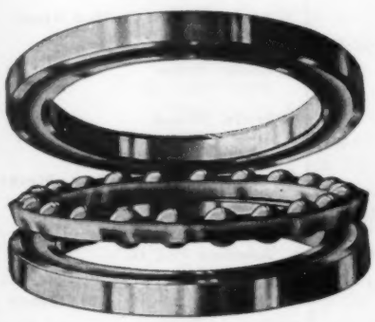

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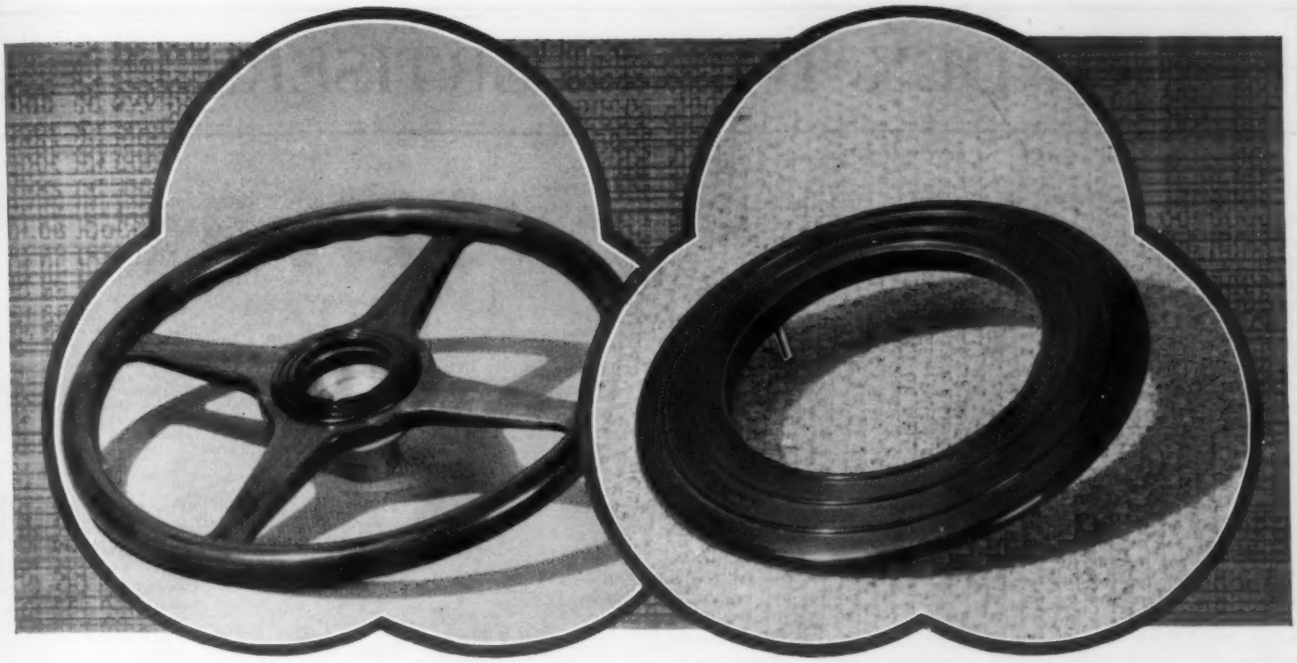

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Bakelite Molded replaces metal— *appearance improved—cost reduced*

THE cover plate ring of this steering wheel was formerly made of aluminum. Through substituting a Bakelite Molded ring five operations were eliminated and the cost of the part reduced approximately fifty per cent. In addition, the use of Bakelite Molded provided accuracy of dimension, durability, lustrous finish, and a color in harmony with the finish of the wheel.

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Intimate knowledge of thousands of varied applications of Bakelite Materials combined with eighteen years' experience in the development of phenol resinoids for automotive uses provides a valuable background for the cooperation offered by our engineers and research laboratories.

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"The registered Trade Mark and Symbol shown above may be used only on products made from materials manufactured by Bakelite Corporation Under the capital "B" is the numerical sign for infinity, or unlimited quantity It symbolizes the infinite number of present and future uses of Bakelite Corporation's products."

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Philadelphia

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LINK-BELT

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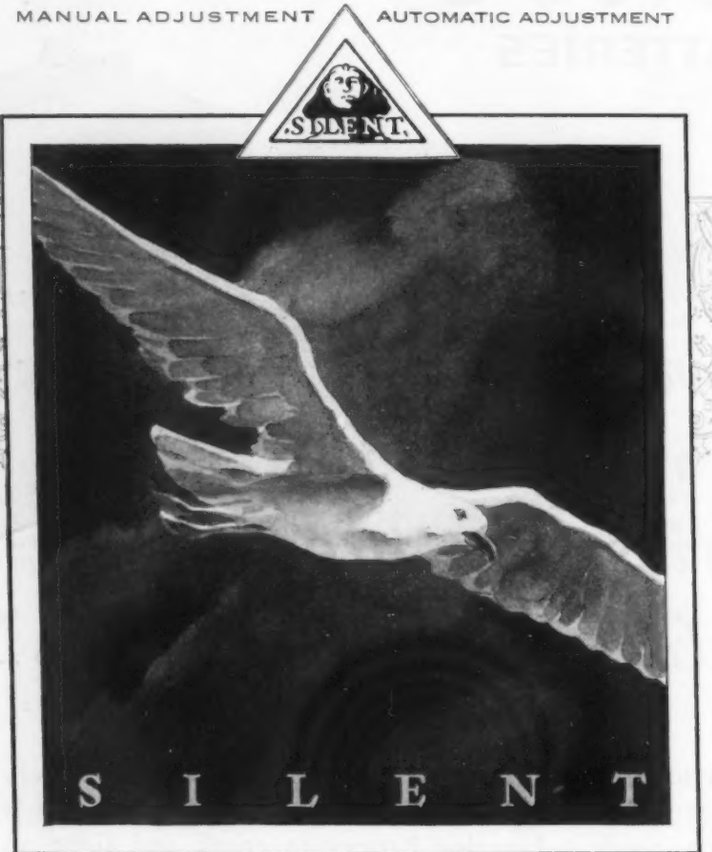
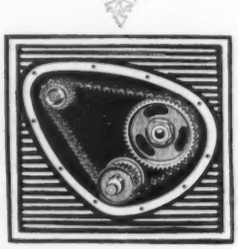
MANUAL ADJUSTMENT AUTOMATIC ADJUSTMENT





Link-Belt Automotive Silent Timing Chains are standard equipment on 45 automobile models, 22 auto motors, 10 busses, 31 trucks and 10 marine motors. Cars in every price class are turning to Link-Belt Silent Timing Chains because they are so quiet, durable and dependable.

LINK-BELT COMPANY . . . INDIANAPOLIS . DETROIT

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When car sales need a tonic!

TERNSTEDT

Impressive beauty . . . . practical convenience . . . . luxurious comfort . . . . is the impetus behind the steady upward swing of sales curves for some car builders . . . . while others are slipping down.

In those motor cars which dominate the various price divisions . . . . in appeal . . . . and sales . . . . Ternstedt interior fittings and appointments conspicuously contribute to the arousing of buyer interest.

Ternstedt is the one organization in the industry prepared to provide *all* phases of a *complete* designing and production service.

The powerful influence of national advertising steadily is increasing the prestige of Fittings by Ternstedt

EXPORT ORGANIZATION
Overseas Motor Service Corporation
New York, N. Y.

TERNSTEDT
MANUFACTURING COMPANY
World's Largest Manufacturers of Automobile Body Hardware
DETROIT U. S. A.

UNIT OF FISHER BODY CORPORATION

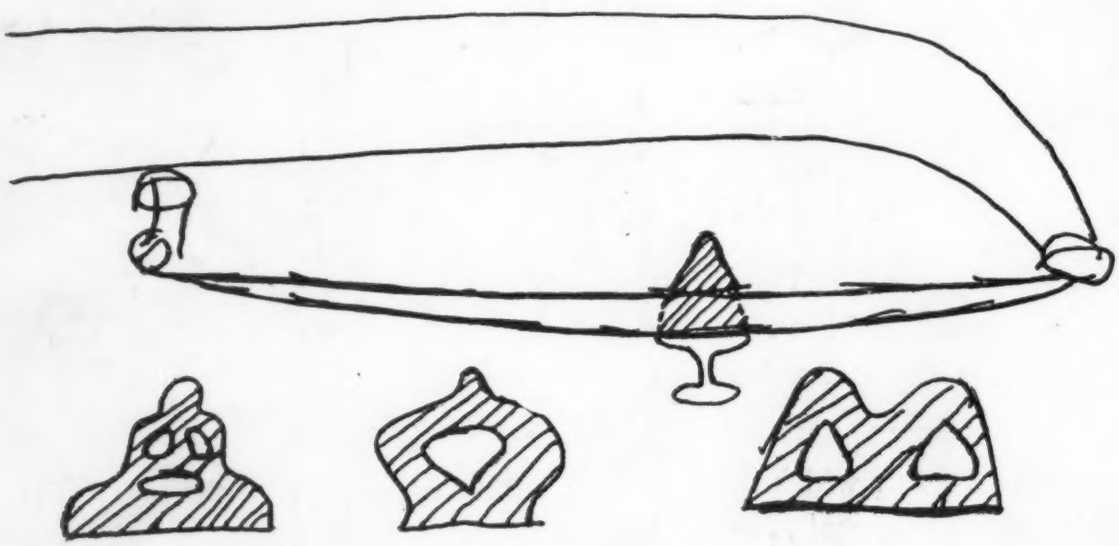
THE only time a car spring does good is when it is yielding. By yielding, a spring cushions us from a road blow. If it wasn't for this yielding, we would be just as well off by using crowbars instead of springs.

Then why employ any device which *interferes* with the yielding of our springs? By so doing we are simply robbing ourselves of the spring's usefulness.

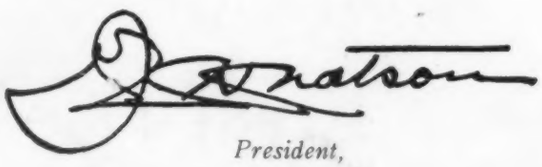
If the spring clearance is so small that we *have* to do something to keep from bottoming, metal to metal, why not employ the simple expedient of a properly contoured rubber bumper?

If the rubber bumper is made out of rubber instead of putty and chewing gum and old rags, the bumper will stay put for years of service. And if such a bumper is placed alongside the spring, instead of between the spring and the frame, it will in no way diminish the available spring travel.

The thing devoid of complications, the simple thing, the ultimate thing, often seems too simple to be worth much. Look over any automobile today though and you will find that its best and most lasting and most trouble-free parts are the simple parts.



Design your own, to come into action just when you want it to, and with any resistance and progressive resistance which will suit you best.



President,

JOHN WARREN WATSON COMPANY